ASHRAE HOUSTON
Standard 90.1 / City of Houston Energy Code Seminar

www.ashraehouston.org

www.ashrae.org

http://documents.publicworks.houstontx.gov/document-center/houston-amendments-and-code-related-documents/ashrae-90.1-2007-houston-amendments/details.htm

ASHRAE HOUSTON
Standard 90.1 / City of Houston Energy Code Seminar

9:00	Introduction	Keith Reihl
9:15	90.1 MEP	Keith Reihl
10:30	Break	
10:45	Appendix G	David McClain
11:15	Lunch	
12:30	City of Houston Forms and Implementation	Lisa Brown

ASHRAE HOUSTON
Standard 90.1 / City of Houston Energy Code Seminar

1:00	90.1 Building Envelope Lisa Rosenow
2:30	90.1 2007 vs 90.1 2010 Keith Reihl
3:00	Closing and questions

SURVEY LINK

http://67.225.150.43/survey.php

ASHRAE HOUSTON
Standard 90.1 / City of Houston Energy Code Seminar

The Energy code allows you to follow:

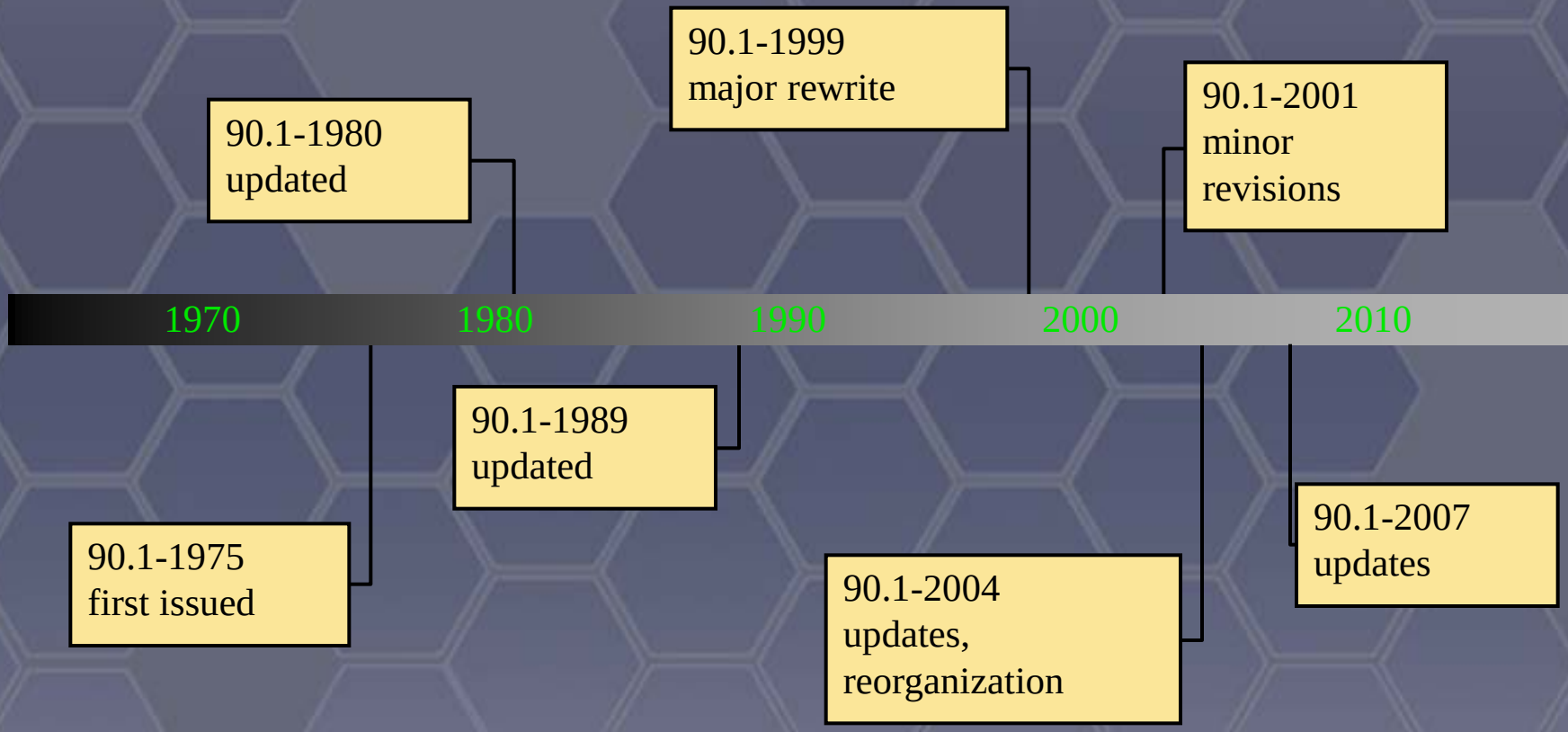
ASHRAE 90.1 2007

- Or -

IECC 2009

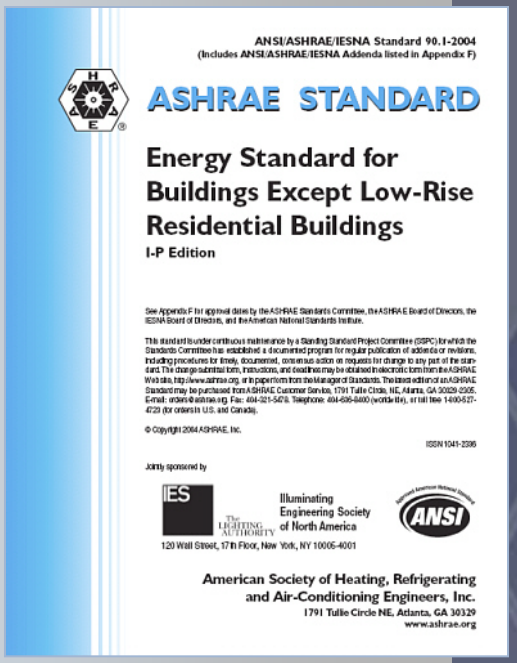
Since IECC 2009 is based upon ASHRAE 90.1 2007 we are only presenting 90.1 today.

90.1 Historical Timeline



ASHRAE Standard 90.1

Purpose



ANSI/ASHRAE/IESNA Standard 90.1-2004
(Includes ANSI/ASHRAE/IESNA Addenda listed in Appendix F)

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

I-P Edition

See Appendix F for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, the IESNA Board of Directors, and the American National Standards Institute.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, http://www.ashrae.org, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

© Copyright 2004 ASHRAE, Inc.

ISSN 1041-2336

Jointly sponsored by

IES The Lighting Authority — Illuminating Engineering Society of North America
120 Wall Street, 17th Floor, New York, NY 10005-4001

ANSI

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle NE, Atlanta, GA 30329
www.ashrae.org

"… Provide minimum requirements for the energy-efficient design of buildings except low-rise residential buildings"

ASHRAE Standard 90.1 and Model Codes

ASHRAE Standard 90.1 is adopted by:

- National Fire Protection Association
- International Code Council (International Energy Conservation Code)
  - IECC–Chapter 8 adopts 90.1-2007 by reference
  - IECC–Chapter 7 describes an alternate path for compliance

ASHRAE Standard 90.1 and LEED®-NC Version 2.2

- EAp2: Minimum energy performance
  - Mandatory provisions of 90.1-2004 and
  - Prescriptive requirements of 90.1-2004 **or** Energy Cost Budget method of 90.1-2004
- EAc1: Optimize energy performance
  - Awards points for improving performance rating of the design building vs. baseline building per 90.1-2004
  - Minimum 14% improvement (2 credit points) is required

ASHRAE Standard 90.1 and LEED®-2009

- EAp2: Minimum energy performance
  - Mandatory provisions of 90.1-2007 and
  - Prescriptive requirements of 90.1-2007 **or** Energy Cost Budget method of 90.1-2007 and
  - 10% improvement over 90.1-2007
- EAc1: Optimize energy performance
  - 1 point for 12% savings
  - 3 points for 16% savings…
  - Up to 19 points (out of 100)

ASHRAE Standard 90.1

Scope

- New buildings and their systems
- New portions of buildings and their systems
- New systems and equipment in existing buildings

ASHRAE Standard 90.1
Exclusions

- Low-rise residential buildings
  - ASHRAE Standard 90.2 covers low-rise (3 stories or less)
- Buildings that do not use either electricity or fossil fuel
- Equipment and portions of building systems that use energy to primarily to provide for industrial, manufacturing, or commercial processes

Standard 90.1

- Under continuous maintenance
- Latest Published 90.1 2010
- 90.1-2007 plus addenda
  - Will highlight a few of the significant addenda

90.1 2010 is

30% stricter than 2004

Standard 90.1 Section 6 HVAC

- Equipment - New equipment shall meet the minimum efficiency requirements
- Cooling systems
  - New cooling systems installed to serve previously uncooled spaces shall comply with this section
  - Alterations to existing cooling systems shall not decrease economizer capacity (unless economizer tradeoff is used)
- Ductwork - New and replacement ductwork shall comply with applicable requirements
- Piping - New and replacement piping shall comply with applicable requirements

Standard 90.1 Section 6 HVAC

- Alterations to the building HVAC system shall comply with the requirements of Section 6
  - Exceptions that are allowed:
    - Equipment being modified or repaired (not replaced)
      - provided such modifications will not result in an increase in the annual energy consumption
    - Equipment being replaced or altered which requires extensive revisions to other systems and such replaced or altered equipment is a like-for-like replacement
    - Refrigerant change of existing equipment
    - Relocation of existing equipment
    - Ducts and pipes where there is insufficient space or access to meet these requirements

Standard 90.1 Section 6 HVAC

- Section 6.2
- You have to follow Sections
  - 6.1 General,
  - 6.7 Submittals, and
  - 6.8 Minimum Equipment Efficiency,
- And then you can follow either
  - Section 6.3 Simplified Approach OR
  - Sections 6.4 Mandatory Provisions and 6.5 Prescriptive Path

  Alternatively, you can follow Section 11 (ECB), in which case Section 6.4 is mandatory

Standard 90.1 Section 6 HVAC

- Simplified Approach is limited to…
  - Buildings with 1 or 2 stories
  - Buildings < 25,000 ft^2
  - Single-zone systems (unitary or split)
  - Air-cooled or evaporatively cooled

Simplified Approach Option *(cont'd)*

Section 6.3

- For 2010 (not right now for climate zone 2a) The system shall have an economizer, unless the economizer Trade-off Option is used
  - Limited to unitary systems
  - Requires higher minimum cooling efficiency (EER)
  - Trade-off EER by
    - System size
    - Climate zone

Table 6.3.2

Simplified Approach Option *(cont'd)*

Section 6.3

- Manual changeover or dual set-point thermostat
- Heat pump supplementary control
- No reheat or simultaneous heating and cooling for humidity control **(RESERVED IN COH)**
- Time clocks (except hotel/motel guest rooms and systems requiring continuous operation)
- Piping and ductwork insulated per Mech Code

Simplified Approach Option *(cont'd)*

Section 6.3

- Balancing of ducted systems by NEBB, AABC or ASHRAE 111
- Interlocked t-stats for separate heating & cooling
- Exhaust : gravity or motorized dampers unless operated continuously
- System > 10,000 cfm: optimum start controls
- Outside air intakes shall have motorized dampers with leakage rate not to exceed 4 cfm at 1.0 in. w.g. cfm per ft2 of damper area. Outside air dampers and exhaust fans shall be interlocked to close the damper and turn off the fan when the supply air system is de-energized.

HVAC Mandatory Provisions

Section 6.4

- Minimum Equipment Efficiency *(Section 6.4.1)*
- Load Calculations *(Section 6.4.2)*
- Controls *(Section 6.4.3)*
- HVAC System Construction and Insulation *(Section 6.4.4)*
- Completion Requirements *(Section 6.4.5)*

HVAC - MP

Equipment Covered

- Package air conditioners and condensing units
- Heat pumps (air, water, and ground source)
- Packaged terminal and room air conditioners
- Chillers including absorption chillers
- Furnaces and unit heaters
- Boilers
- Heat rejection equipment

Mechanical Equipment Efficiency

Section 6.4.1

- Tables 6.8.1A – 6.8.1G
- Tables 6.8.1H-6.8.1J used for water cooled centrifugal chillers that operate at non-standard rating conditions
- Combination HVAC and water heating systems to meet all requirements for appropriate space heating or cooling category
- Gas-fired and oil-fired forced air furnaces with input ratings ≥ 225,000 Btu/h to have intermittent or interrupted ignition device and have either power venting or a flue damper
- All furnaces with input ratings ≥ 225,000 Btu/h, including electric furnaces, not located in conditioned space, to have jacket losses
  ≤ 0.75% of the input rating

HVAC - MP

Verification of Equipment Efficiencies

Section 6.4.1.4

Equipment efficiency information from manufacturers verified as follows:

- EPACT equipment – to comply with DOE certification requirements
- If certification program exists for covered product and includes provisions for verification and challenge of equipment efficiency ratings, product listed in program OR
- If product not listed in program, ratings verified by an independent laboratory test report OR
- If no certification program exists, equipment efficiency ratings supported by data furnished by manufacturer OR
- Where components from different manufacturers are used, system designer specifies components whose combined efficiency meets Section .4.1
- Products in Table 6.8.1G shall have efficiency ratings supported by data furnished by manufacturer.

HVAC - MP

Labeling

Section 6.4.1.5

- Mechanical equipment (6.4.1.5.1) – equipment not covered by NAECA shall carry a permanent label stating equipment complies with 90.1
- Packaged terminal air conditioners (6.4.1.5.2) – packaged terminal air conditioners and heat pumps with sleeve sizes
  < 16 in. high and 42 in. wide shall be factory labeled as follows:
  - *Manufactured for replacement applications only: not to be installed in new construction projects*

HVAC - MP

Load Calculations

Section 6.4.2

- Must calculate heating and cooling system design loads
- Must base calculations on generally accepted engineering standards and handbooks
- Appendix G

HVAC - MP

Controls – Zone Thermostatic and Dead Band

Section 6.4.3.1

- Required for each zone
  - Perimeter can be treated differently
- Dead band controls
  - Thermostats must have at least a 5°F dead band
  - Exceptions
    - Thermostats that require manual changeover between heating and cooling modes
    - Special occupancy or applications where wide temperature ranges aren't acceptable (e.g., retirement homes) and approved by adopting authority

HVAC - MP

Controls – Setpoint Overlap Restriction

Section 6.4.3.2

- If limit switches, mechanical stops, or software programming for DDC systems are used
  - means will be provided to prevent the heating setpoint from exceeding the cooling setpoint minus any applicable proportional band

HVAC - MP

Controls – Off-Hour

Section 6.4.3.3

- Automatic shutdown
- Setback controls
- Optimum start
- Zone isolation
- Exceptions, HVAC systems
  - with heating/cooling capacity < 15,000 Btu/h
  - intended to operate continuously

HVAC - MP

Controls - Automatic Shutdown

Section 6.4.3.3.1

- Automatic 7-day/week time clock with 10-hour battery backup
  - Exception: 2-day/week thermostat for residential applications
- Each control to have
  - Occupant sensor, **OR**
  - Manually-operated timer with maximum two hour duration, **OR**
  - Security system interlock
- Exception
  - Residential occupancies allowed to operate with only 2 different time schedules/wk

HVAC - MP

Controls - Setback

Section 6.4.3.3.2

- Climate Zones 2-8
  - Lower heating setpoint to 55ºF or less
- Climate Zones 1b, 2b, 3b (hot/dry)
  - Automatically restart, temporarily operate
    - Raise cooling setpoint to 90ºF or higher **OR**
    - Prevent high space humidity levels

HVAC - MP

Controls - Optimum Start

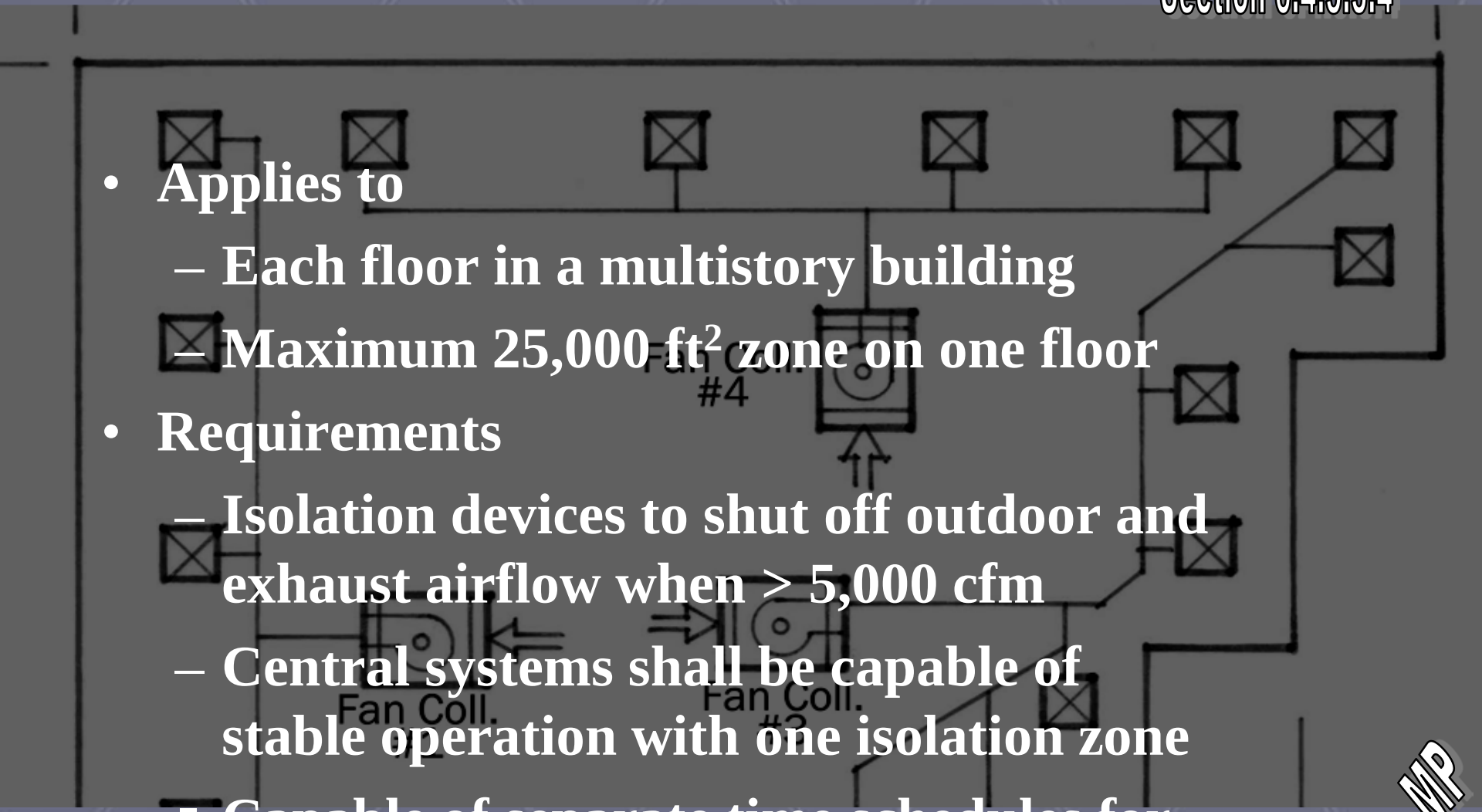
Section 6.4.3.3.3

- Individual heating and cooling air distribution systems with
  - Total design supply air capacity > 10,000 cfm
  - Served by one or more supply fans
- Control algorithm to at least be a function of
  - Difference between space temperature and occupied setpoint and amount of time prior to scheduled occupancy

HVAC - MP

Controls - Zone Isolation

Section 6.4.3.3.4



- **Applies to**
  - **Each floor in a multistory building**
  - **Maximum 25,000 ft^2 zone on one floor**
- **Requirements**
  - **Isolation devices to shut off outdoor and exhaust airflow when > 5,000 cfm**
  - **Central systems shall be capable of stable operation with one isolation zone**
    - **Capable of separate time schedules for each isolation zone**

HVAC - MP

Controls – Ventilation System *(cont'd)* Stair and Shaft Vents

Section 6.4.3.4

- Motorized dampers
  - Can be automatically closed during normal building operation
  - Interlocked to open as required by fire and smoke detection systems

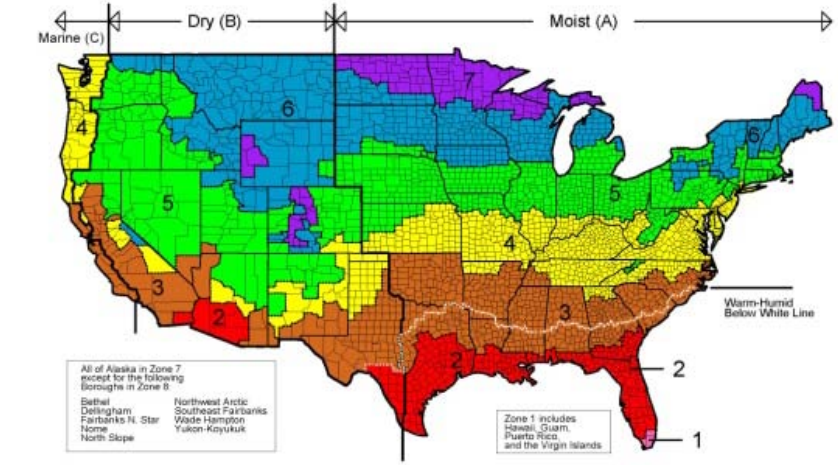
Section 6.4.3.4.1

HVAC - MP

Gravity Hoods, Vents, and Ventilators

Section 6.4.3.4.2

- Motorized dampers to automatically shut when spaces served are not in use are not required since we are in Climate zone 2, Gravity is OK.
- Not required if non air conditioned space or prohibited by the mech. code.



HVAC - MP

Controls - Shutoff Damper

Section 6.4.3.4.3

- Motorized dampers for outdoor air supply and exhaust systems not required in our climate zone, gravity dampers are OK.
- Ventilation outside air dampers to be capable of automatically shutting off during
  - Preoccupancy building warm up, cool down, and setback

(Except when ventilation reduces energy costs or when ventilation must be supplied to meet code requirements)

Table 6.4.3.3.4 provides maximum leakage rates for outdoor air supply and exhaust dampers

HVAC - MP

Dampers

Section 6.4.3.4.4

- Where OA supply and exhaust air dampers are required by Section 6.4.3.4
  - They shall have a maximum leakage rate when tested in accordance with AMCA Standard 500 as indicated in Table 6.4.3.4.4
  - DELETED LEAKAGE AND REFERENCED MECH CODE!

HVAC - MP

Ventilation Fan Controls

Section 6.4.3.4.5

- Fans with motors > 0.75 hp shall have automatic controls complying with Section 6.4.3.3.1 that are capable of shutting off fans when not required
- Exception
  - HVAC systems intended to operate continuously

Heat Pump Auxiliary Heat Control

Section 6.4.3.5

- Controls to prevent supplementary heat when heat pump can handle the load
- Exception
  - Heat pumps
    - With minimum efficiency regulated by NAECA
    - With HSPF rating meeting Table 6.8.1B

  (Includes all usage of internal electric resistance heating)

HVAC - MP

Controls - Humidifier Preheat

Section 6.4.3.6

- Automatic valve to shut off preheat when humidification isn’t required

HVAC - MP

Controls - Humidification and Dehumidification

Section 6.4.3.7

- Provide means to prevent simultaneous operation of humidification and dehumidification equipment
  - Limit switches, mechanical stops, or software programming (DDC systems)
- Exceptions
  - Zones served by desiccant systems, used with direct evaporative cooling in series
  - Systems serving zones where specific humidity levels are required and approved by jurisdiction
    - Museums and hospitals

HVAC - MP

Controls - Freeze Protection and Snow/Ice

Section 6.4.3.8

- Automatic controls for
  - Freeze protection systems
    - outside air temperatures > 40°F or when conditions of protected fluid will prevent freezing
  - Snow- and ice-melting systems
    - pavement temperature > 50°F and no precipitation is falling and outdoor temperature > 40°F

OK, Your asleep if your not questioning this one.. ☺

HVAC - MP

Ventilation Controls for High-Occupancy Areas

Section 6.4.3.9

- *DCV* must be provided for each zone with a area > 500 ft² and the design occupancy > 40 people/1000 ft² where the HVAC system has:
  - An air-side economizer,
  - Automatic modulating control of the OSA dampers, or
  - A design outdoor airflow > 3,000 cfm

Demand control ventilation (DCV): a ventilation system capability that provides for the automatic reduction of outdoor air intake below design rates when the actual occupancy of spaces served by the system is less than design occupancy.

HVAC - MP

Ventilation: High Occupancy Exceptions

- Exceptions:
  - Systems with exhaust-air energy recovery complying with Section 6.5.6.1
  - Multiple zone systems without DDC to the zone level
  - Systems with a design OA airflow <1,200 cfm
  - Spaces where supply-exhaust <1,200 cfm

HVAC System Construction and Insulation

Section 6.4.4

- Insulation installed in accordance with industry-accepted standards
- Insulation protection
- Duct and plenum insulation
- Piping insulation
- Duct sealing
- Duct leakage tests
- IN ACCORDANCE WITH MECH CODE!!

HVAC - MP

General

Section 6.4.4.1.1

- Insulation installed in accordance with industry-accepted standards
- Insulation
  - Protected from damage due to sunlight, moisture, equipment maintenance, and wind
  - Exposed to weather to be suitable for outdoor service
  - Covering chilled water piping, refrigerant suction piping, or cooling ducts located outside the conditioned space to include a vapor retardant located outside the insulation, all penetrations and joints of which to be sealed

HVAC - MP

Duct and Plenum Insulation

Section 6.4.4.1.2

- All supply and return ducts and plenums to be insulated per Tables 6.8.2A and 6.8.2B
- Exceptions
  - Factory-installed plenums, casings, or ductwork furnished as part of HVAC equipment
  - Ducts located in heated, semi-heated, or cooled spaces
  - For runouts < 10 ft in length to air terminals or air outlets, the R-value need not exceed R-3.5
  - Backs of air outlets and outlet plenums exposed to unconditioned or indirectly conditioned spaces with face areas > 5 ft^2 need not exceed R-2; those $\leq$ 5 ft^2 need not be insulated

HVAC - MP

Piping Insulation

Section 6.4.4.1.3

- Table 6.8.3
- Exceptions
  - Factory-installed
  - Piping conveying fluids
    - design operating temperature range between 60°F-105°F, inclusive
    - that haven't been heated or cooled through the use of nonrenewable energy or where heat gain or heat loss will not increase energy usage
  - Hot water piping between shut off valve and coil, not > 4 ft in length, when located in conditioned spaces
  - Pipe unions in heating systems (steam, steam condensate, and hot water)

HVAC - MP

Duct Sealing

Section 6.4.4.2

- Table 6.4.4.2A
- Requirements of 6.4.4.2
- Based on standard industry practice and definitions
- IN ACCORDANCE WITH MECH CODE!!

Table 6.4.4.2A

Minimum Duct Seal Level

Duct Location	Duct Type			
	Supply		Exhaust	Return
	≤2 in. w.c.†	>2 in. w.c.†		
Outdoors	A	A	C	A
Unconditioned Spaces	B	A	C	B
Conditioned Spaces**	C	B	B	C

* See Table 6.4.4.2B definition of Seal Level.
† Duct design static pressure classification.
** Includes indirectly conditioned spaces such as return air plenums.

HVAC - MP

Duct Leakage Tests

Section 6.4.4.2.2

- Designed > 3 in. w.c.
  - Leak tested
  - Representative sections ≥ 25% of the total installed duct area shall be tested
  - Ratings > 3 in. w.c. to be identified on drawings
  - Maximum permitted duct leakage
    - $L_{max} = C_L P^{0.65}$

Where L_{max} = maximum permitted leakage in cfm/100 ft^2 duct surface area

HVAC - MP

Completion Requirements

Section 6.4.5

- Refers to Section 6.7 for Submittal and Completion Requirements including
  - Record drawings
  - Operating and maintenance manuals
  - System balancing
  - **System commissioning**

HVAC - MP

Prescriptive Requirements

proposed HVAC design

mandatory provisions (§6.4)

prescriptive requirements (§6.5)

Energy Cost Budget Method (ECB, §11)

Simplified Approach Option (§6.3)

(small buildings only)

90.1-compliant HVAC system

HVAC Prescriptive Path

Section 6.5

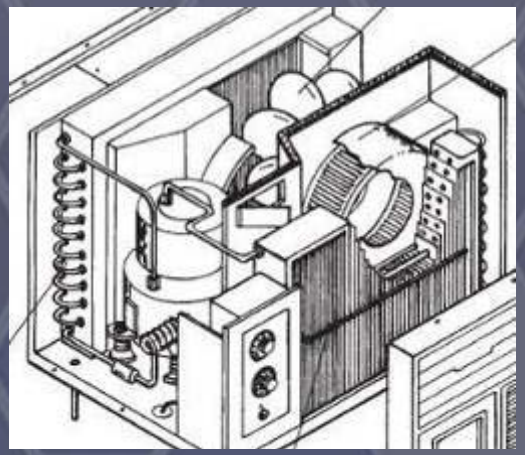
- Economizers *(Section 6.5.1)* ***Coming in 2010!!!***
- Simultaneous Heating and Cooling Limitation *(Section 6.5.2)*
- Air System Design and Control *(Section 6.5.3)*
- Hydronic System Design and Control (*Section 6.5.4)*
- Heat Rejection Equipment *(Section 6.5.5)*
- Energy Recovery *(Section 6.5.6)*
- Exhaust Hoods *(Section 6.5.7)*
- Radiant Heating Systems *(Section 6.5.8)*
- Hot Gas Bypass Limitation *(Section 6.5.9)*

HVAC - P

Zone Controls

Section 6.5.2.1

- Capable of operating in sequence the supply of heating and cooling energy to the zone
- Controls prevent
  - Reheating
  - Recooling
  - Mixing or simultaneously supplying air previously heated or cooled
  - Other simultaneous operation of heating and cooling systems to the same zone



HVAC - P

Zone Controls - Exceptions

Section 6.5.2.1

- Zones for which volume of air that is reheated, recooled, or mixed is no greater than the larger of the following
  - Volume of outside air to meet 6.2 of ASHRAE 62 for the zone
  - 0.4 cfm/ft^2 of zone conditioned floor area
  - 30% of zone design peak supply
  - 300 cfm for zones whose peak flow rate totals no more than 10% of the total fan system flow rate
  - Any higher rate that can be demonstrated to jurisdiction to reduce overall system annual energy usage
- Zones where special pressurization relationships, cross-contamination requirements, or code-required minimum circulation rates are such that the variable air volume systems are impractical

HVAC - P

Hydronic System Controls

Section 6.5.2.2

- Limit heating and cooling of fluids previously heated or cooled mechanically per 6.5.2.2.1 through 6.5.2.2.3

Three-Pipe System

Section 6.5.2.2.1

No common return system for both hot and chilled water

HVAC - P

Two-Pipe Changeover System

Section 6.5.2.2.2

- SHALL NOT BE USED!!
- Common distribution system acceptable if
  - Deadband from one mode to another is ≥ 15°F outside air temperature
  - Controls to allow operation of ≥ 4 hours before changing over
  - Reset controls so heating and cooling supply temperatures at changeover point no more than 30°F apart

HVAC - P

Hydronic (Water Loop) Heat Pump Systems

Section 6.5.2.2.3

- Controls to provide heat pump water supply temperature deadband of at least 20°F between initiation of heat rejection and heat addition by central devices
- Cooling tower bypass or cooling tower isolation dampers
- A two-position valve at each hydronic heat pump for hydronic systems having a total pump system power > 10 hp
- Exception
  - If system loop temperature optimization controller is used, deadband < 20°F is allowed

HVAC - P

Dehumidification

Section 6.5.2.3

- Humidistatic controls to prevent
  - Reheating
  - Mixing of hot and cold air streams
  - Heating and cooling of same air stream

HVAC - P

Dehumidification Exceptions

Section 6.5.2.3

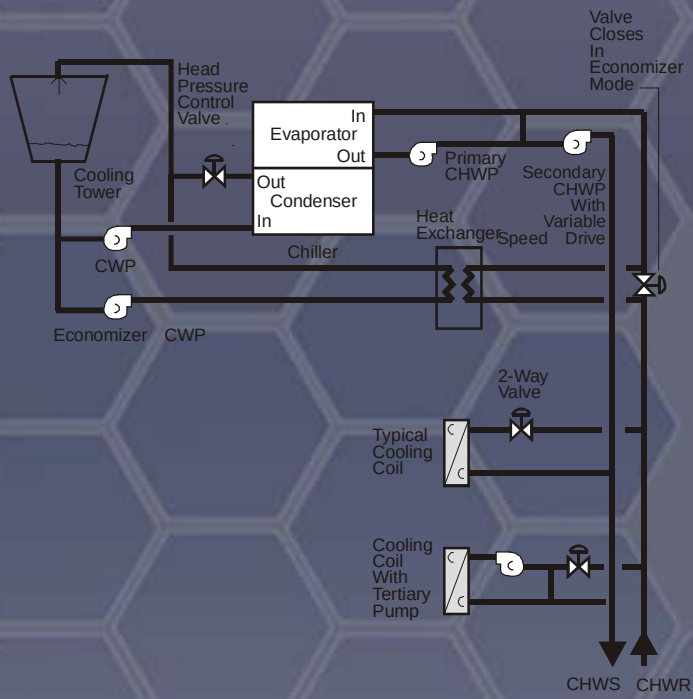
- FOR THE PURPOSES OF HUMIDITY CONTROL!!
- Systems capable of reducing supply air flow to 50%, or to minimum ventilation
- Systems under 6.67 tons that can unload at least 50%
- Systems smaller than 3.3 tons
- Process applications
- 75% of reheat or recool energy is recovered or solar

HVAC . P

Humidification

Section 6.5.2.4

- Systems with hydronic cooling and humidification systems designed to maintain inside humidity at > 35°F dewpoint temperature shall use a water economizer if required by 6.5.1



HVAC - P

Air System Design and Control

Section 6.5.3

- RESEVED!!
- HVAC systems with total fan system power
  > 5 hp to meet 6.5.3.1 through 6.5.3.2
  - Fan Power Limitation
  - VAV Fan Control
    - Part Load Fan Power Limitation
    - Static Pressure Sensor location
    - Set Point Reset

HVAC - P

Fan Power Limitation

Section 6.5.3.1

- RESEVED!!
- Table 6.5.3.1
- Allowable fan system power may be adjusted if
  - Air systems require air treatment or filtering systems with pressure drops > 1 in. w.c. when filters are clean, or heat recovery coils or devices, or direct evaporative humidifiers/coolers, or other devices to serve process loads in the airstream
  - design room temperature – supply air temp at cooling design condition = > 20°F, allowable fan system power may be adjusted
- Exceptions

HVAC - P

Motor Nameplate Horsepower

- Selected fan motor to be no larger than first available motor size greater than bhp
- Fan bhp on design documents
- Exceptions
  - Fans < 6 bhp, where first available motor larger than bhp has nameplate rating within 50% of bhp, next larger nameplate motor size may be selected
  - Fans ≥ 6 bhp, where first available motor larger than bhp has nameplate rating within 30% of bhp, next larger nameplate motor size may be selected

Part-Load Fan Power Limitation

Section 6.5.3.2.1

- Individual VAV fans with motors ≥ **5** hp reduced from 10 hp.
  - Must have either:
    - Variable Speed Drive
    - Vane axial fan with variable-pitch fan blades
    - Other controls and devices to result in fan motor demand ≤ 30% of design wattage at 50% of design air volume when static pressure set point = 1/3 of total design static pressure, based on manufacturer's certified fan data

HVAC - P

Static Pressure Sensor Location

Section 6.5.3.2.2

- REPLACED with requirement for ECM's except parallel flow boxes with little fan operation
- Placed so controller set point is ≤ 1/3 the total design fan static pressure
  - Except for digital control systems with zone reset capabilities where it may be at the fan discharge
- Install multiple sensors in each major branch if sensor would be located downstream of a major duct split

HVAC - P

Set Point Reset

Section 6.5.3.2.3

- For systems with direct digital control of individual zone boxes reporting to the central control panel
  - Static pressure set point reset based on zone requiring the most pressure

HVAC - P

Hydronic System Design and Control

Section 6.5.4

- HVAC hydronic systems with total pump system power > 10 hp shall meet 6.5.4.1 – 6.5.4.4
  - Hydronic Variable Flow Systems
  - Pump Isolation
  - Chilled and Hot Water Temperature Reset
  - Hydronic (water-loop) Heat Pump Systems

HVAC - P

Hydronic Variable Flow

Section 6.5.4.1

- HVAC pumping systems to include control valves
  - Designed to modulate or step open and close as a function of load
  - Designed for variable fluid flow
  - Capable of reducing flow rates to ≤ 50% of design flow rate
- Individual pumps serving variable flow systems with a pump head > 100 ft and motor > 50 hp
  - Have controls and/or devices resulting in pump motor demand ≤ 30% of design wattage at 50% of design water flow

HVAC - P

Hydronic Variable Flow - Exceptions

Section 6.5.4.1

- Systems where
  - Minimum flow is < minimum flow required by equipment manufacturer for proper operation of equipment served by the system
  - REMOVED Total pump system power ≤ 75 hp
- Systems that include ≤ 3 control valves

HVAC - P

Pump Isolation

Section 6.5.4.2

- If chilled water plant has more than one chiller or boiler plant has more than one boiler
  - Provide for flow reduction when chiller or boiler is shut down

HVAC - P

Chilled and Hot Water Temperature Reset Controls

Section 6.5.4.3

- Affects systems with design capacity > 300,000 Btu/h
  - To include controls to automatically reset supply water temperatures by representative building loads (including return water temperature) or by outside air temperature
- Exceptions
  - If controls would result in improper operation
  - Hydronic systems with variable flow

HVAC - P

Hydronic Heat Pump

Section 6.5.4.4

- For heat pump loops with total pump system power > 10 hp
  - Two-position valves at each hydronic heat pump must be provided and interlocked to shut off water flow to the heat pump when the compressor is off
    - This basically converts the system into a variable flow system. As such, these systems must also comply with 6.3.4.1

HVAC - P

Heat Rejection Equipment

Section 6.5.5

- RESERVED!!
- Applies to heat rejection equipment used in comfort cooling systems such as
  - Air-cooled condensers
  - Open cooling towers
  - Closed-circuit cooling towers
  - Evaporative condensers
- Exceptions
  - Heat rejection devices included as an integral part of equipment listed devices whose energy usage is included in Tables 6.8.1A-6.8.1D

HVAC - P

Fan Speed Control

Section 6.5.5.2

- RESERVED!!!
- Each fan powered by a motor ≥ 7.5 hp
  - Have capability to operate fan at ≤ 2/3 full speed
  - Have controls to automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device
- Exceptions
  - Condenser fans serving multiple refrigerant circuits or flooded condensers
  - Installations located in climates zones 1 and 2
  - 1/3 of the fans on a multiple fan application speed controlled

HVAC - P

Exhaust Air Energy Recovery

Section 6.5.6.1

- Incorporate exhaust air energy recovery in systems with
  - ≥ 70% outside air and ≥ 5000 cfm total
  - DELETED -50% energy recovery effectiveness

HVAC - P

Exhaust Air Energy Recovery Exceptions

Section 6.5.6.1

- Lab fume hood systems and biological safety cabinets
- Systems serving uncooled spaces that are heated to < 60°F
- Systems exhausting toxic, flammable, paint or corrosive fumes or dust
- Commercial kitchen hoods used for collecting grease or smoke
- Where > 60% of outdoor heating energy is provided from site-recovered or site solar energy
- Heating systems in climate zones 1 through 3 2
- Cooling systems in climate zones 3c, 4c, 5b, 5c, 6b, 7, and 8
- Where largest exhaust source is < 75% of the design outdoor airflow
- Systems requiring dehumidification that employ energy recovery in series with the cooling coil

HVAC - P

Heat Recovery for Service Water Heating

Section 6.5.6.2

- DELETED!!
- Condenser recovery required if
  - 24 hrs per day **and**
  - Heat rejection > 6,000,000 Btu/h **and**
  - SWH load > 1,000,000 Btu/h
- Exceptions

HVAC - P

Kitchen Hoods (Exhaust)

Section 6.5.7.1

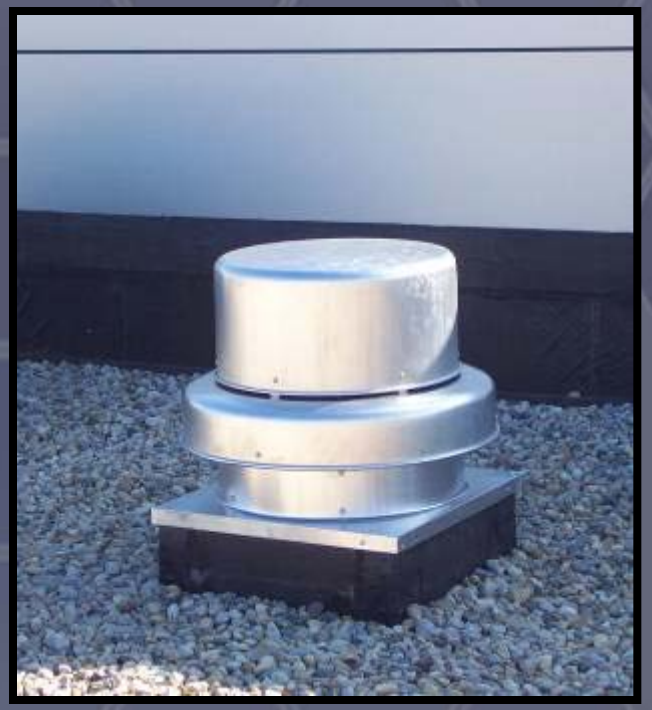
- RESERVED!
- Hoods > 5,000 cfm to be provided with makeup air sized for at least 50% of exhaust air volume that is a) unheated or heated to more than 60°F and b) uncooled or cooled without the use of mechanical cooling
- Exceptions
  - Where hoods are used to exhaust ventilation air that would otherwise exfiltrate or be exhausted by other fan systems
  - Certified grease extractor hoods that require a face velocity no greater than 60 fpm

HVAC - P

Fume Hoods

Section 6.5.7.2

- RESERVED!!
- Hood systems with a total exhaust rate > 15,000 cfm to have ONE of the following features
  - Operation to < 50% design flow **OR**
  - Direct make up at least 75% of exhaust rate at specified conditions **OR**
  - Heat recovery for make-up air



HVAC - P

Radiant Heating Systems

Section 6.5.8

- Required for unenclosed spaces except loading docks with air curtains
- “Radiant heating systems that are used as primary or supplemental enclosed space heating must be in conformance with the governing provisions of the standard”

HVAC - P

Hot Gas Bypass Limitation

Section 6.5.9

- Not used (including other evaporator pressure control systems) unless system is designed with multiple steps of unloading or continuous capacity modulation
- Exception
  - Unitary packaged systems with cooling capacities ≤ 90,000 Btu/h

HVAC - P

Submittals

Section 6.7

- Record drawings
- Operating and maintenance manuals
- System balancing - Each supply outlet and zone terminal device shall be equiped with means for air balancing!!
- System commissioning – BOTH Building Envelope and Systems Commissioning is required by COH!!

HVAC - MP

Drawings

Section 6.7.2.1

- Record drawings of actual installation to building owner within 90 days of system acceptance and include, as a minimum
  - Location and performance data on each piece of equipment
  - General configuration of duct and pipe distribution system including sizes
  - Terminal air or water design flow rates

Manuals

Section 6.7.2.2

- Operating and maintenance manuals to building owner within 90 days of system acceptance and include several items

HVAC - MP

System Balancing

Section 6.7.2.3

- Systems shall be balanced in accordance with accepted engineering standards
- NEBB, AABC, ASHRAE 111
- Written report for conditioned spaces > 5000 ft^2
- Minimize throttling losses
- For fans with system power > 1 hp
  - Adjust fan speed to meet design flow conditions

HVAC - MP

Hydronic System Balancing

Section 6.7.2.3.3

- Proportionately balanced to minimize throttling losses
- Pump impeller trimmed or pump speed adjusted to meet design flow conditions
- Each system to have either the ability to measure differential pressure increase across the pump or have test ports at each side of the pump
- Exceptions
  - Pumps with pump motors ≤ 10 hp
  - When throttling results in < 5% of the nameplate hp draw, or 3 hp, whichever is greater, above that required if the impeller was trimmed

HVAC - MP

System Commissioning

- Control elements are calibrated, adjusted, and in proper working condition
- > 50,000 ft^2 conditioned area
  - Except warehouses and semiheated spaces
  - Requires commissioning instructions

Section 6.7.2.4

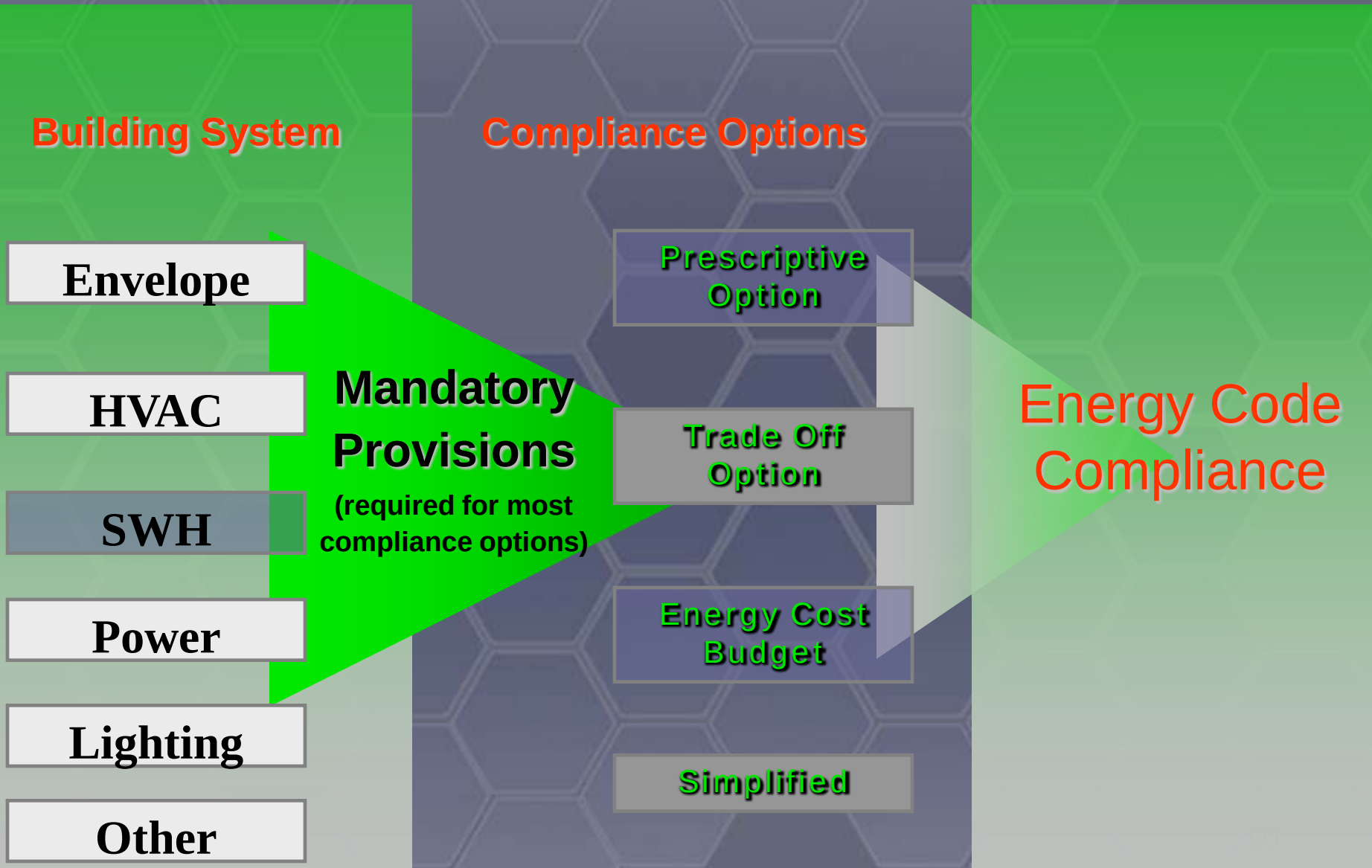
HVAC - MP

Minimum Equipment Efficiency Tables

Section 6.8

- Equipment efficiency tables 6.8.1A to 6.8.1J
- Duct Insulation Tables 6.8.2A and 6.8.2B
- Pipe Insulation Table 6.8.3

SWH Compliance



Section 7 - Service Water Heating

- General *(Section 7.1)*
- Compliance Path(s) *(Section 7.2)*
- Mandatory Provisions *(Section 7.4)*
  - Load calculations
  - Equipment efficiency
  - Service hot water piping insulation
  - System controls
  - Pools
  - Heat traps
- Prescriptive Path *(Section 7.5)*
  - Space heating and water heating
  - Service water heating equipment
- Submittals *(Section 7.7)*

SWH Alterations

Section 7.1.1.3

- SWH equipment installed as a direct replacement shall meet these requirements unless there is not sufficient space or access to meet these requirements

SWH Compliance Paths

- Section 7.2
- You have to follow Sections
  - 7.1,
  - 7.4,
  - 7.5,
  - 7.7, and
  - 7.8
- Alternatively, you can follow Section 11 (ECB), in which case Section 7.4 is mandatory

Load Calculations

Section 7.4.1

- In accordance with manufacturer's published sizing guidelines or generally accepted engineering standards and handbooks

SWH - MP

Equipment Efficiency

Section 7.4.2

- Section 7.4.2 refers to Table 7.8 for equipment efficiencies
- Equipment not listed in Table 7.8 has no minimum performance requirements
- Exception
  - Water heaters and hot water supply boilers > 140 gal storage capacity don't have to meet standby loss requirements when
    - Tank surface is thermally insulated to R-12.5, and
    - A standing pilot light isn't installed, and
    - Gas- or oil-fired water heaters have a flue damper or fan-assisted combustion

SWH - MP

Service Hot Water Piping Insulation

Section 7.4.3

- Table 6.8.3, Section 6
- Circulating water heater
  - Recirculating system piping, including supply and return piping
- Nonrecirculating storage system
  - ALL Piping!! First 8 ft of outlet piping
  - Inlet pipe between storage tank and heat trap
- Externally-heated pipes (heat trace or impedance heating)

SWH - MP

Service Water Heating System Controls

Section 7.4.4

- Temperature Controls
- Temperature Maintenance Controls
- Outlet Temperature Controls
- Circulating Pump Controls

SWH - MP

Temperature Controls

Section 7.4.4.1

- To allow for storage temperature adjustment from 120°F or lower to a maximum temperature compatible with the intended use
- Exception
  - If manufacturer's installation instructions specify a higher minimum thermostat setting to minimize condensation and resulting corrosion

SWH - MP

Temperature Maintenance Controls

Section 7.4.4.2

- Automatic time switches or other controls
  - Set to switch off usage temperature maintenance system during extended periods when hot water is not required

SWH - MP

Outlet Temperature Controls

- Controls provided
  - To limit maximum temperature of water delivered from lavatory faucets in public facility restrooms to 110°F

Section 7.4.4.3

SWH - MP

Circulating Pump Controls

Section 7.4.4.4

- To limit operation to a period from the start of the heating cycle to a maximum of five minutes after the end of the heating cycle

SWH - MP

Pools

Section 7.4.5

- Pool heaters to have readily accessible on-off switch
- Pool heaters fired by natural gas can NOT have continuously burning pilot lights
- Vapor retardant pool covers required (unless recovered or solar heat)
- Time switches required

SWH - MP

Heat Traps

Section 7.4.6

- Noncirculating systems to have heat traps on both the inlet and outlet piping as close as practical to storage tank (if no integral heat traps)
  - Either a device specifically designed for this purpose or
  - Arrangement of tubing that forms a loop of 360° or piping that from the point of connection to the water heater includes a length of piping directed downward before connection to the vertical piping of the supply water or hot water distribution system, as applicable

SWH - MP

Space Heating and Water Heating

- Gas- or oil-fired space heating boiler system (complying with Section 6) is allowed to provide total space heating and water heating when ONE of the following conditions is met
  - Single boiler or component that is heating the service water has a standby loss in Btu/h not exceeding
    - (13.3 x *pmd* + 400) / *n*; where *pmd* is probable maximum demand in gal/h and *n* is the fraction of the year when outdoor daily mean temperature is > 64.9°F
  - Jurisdiction agrees use of a single heat source will consume less energy than separate units
  - Energy input of the combined boiler and water heater system is < 150,000 Btu/h
- Instructions for determining standby loss are included in this Section

Section 7.5.1

SWH - P

Service Water Heating Equipment

Section 7.5.2

- Equipment used to provide the additional function of space heating as part of a combination (integrated) system shall satisfy all requirements for service water heating equipment

SWH - P

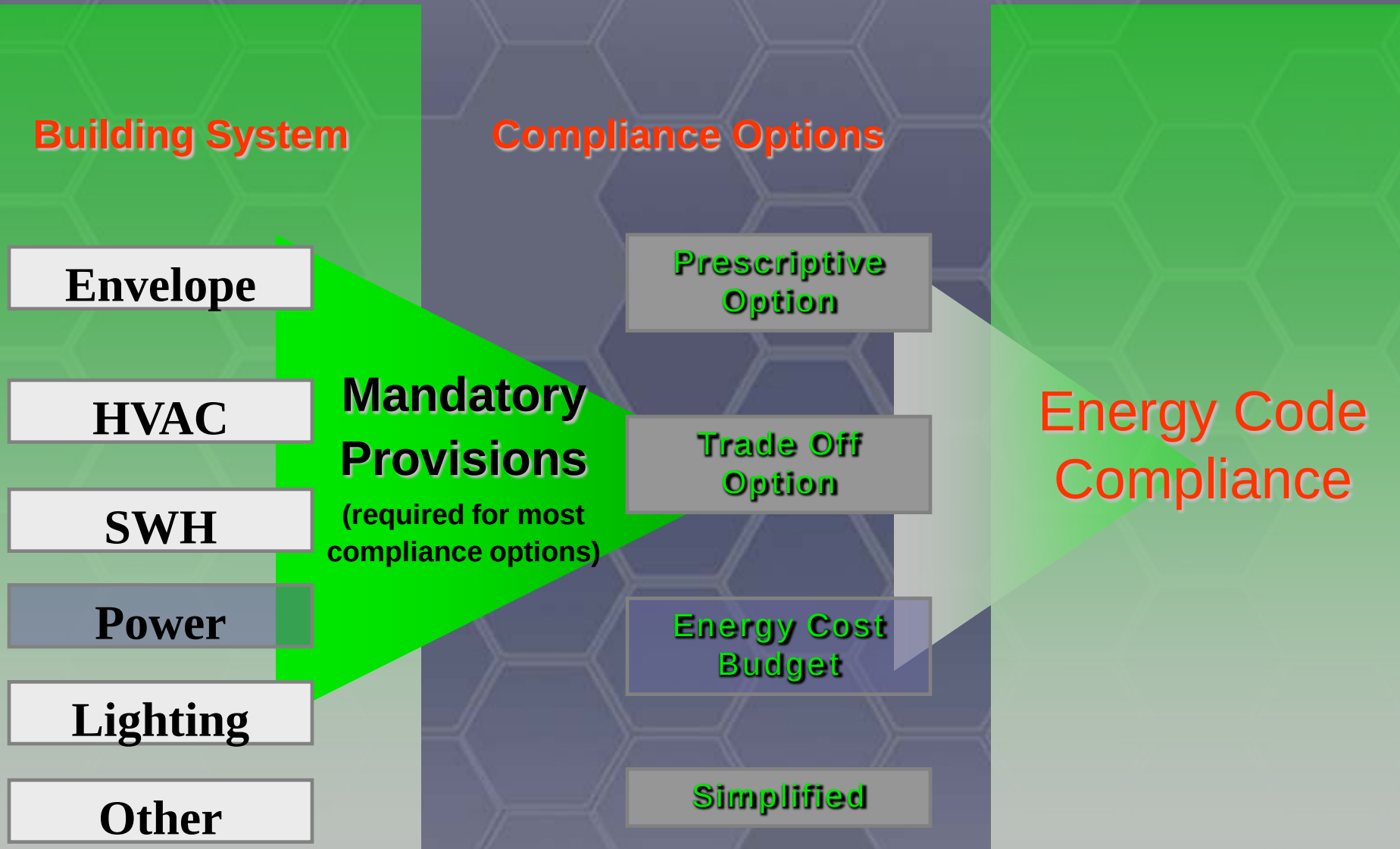
Service Water Heating Submittals

Section 7.7

- Authority having jurisdiction may require submittal of compliance documentation and supplemental information in accord with Section 4.2.2 of this standard

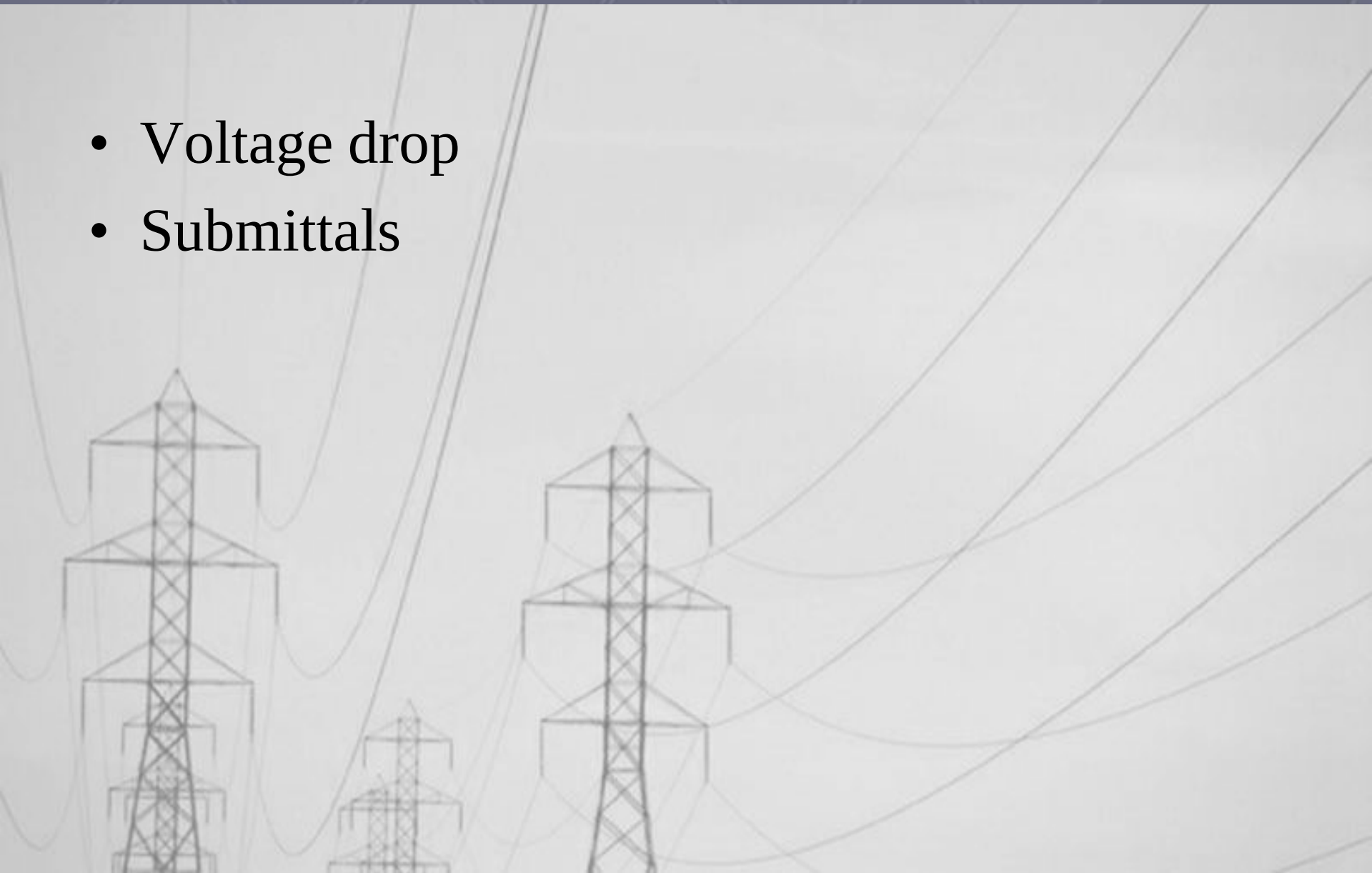
SWH - P

Power Compliance



Section 8 - Power

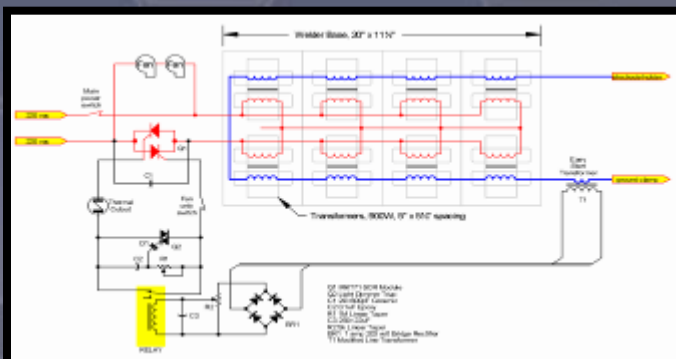
- Voltage drop
- Submittals



Voltage Drop

Section 8.4.1

- Two types of conductors
  - Feeder conductors
    - Connect service equipment to the branch circuit breaker panels
    - 2% maximum voltage drop allowed at design load
  - Branch circuit conductors
    - Run from the final circuit breaker to the outlet or load
    - 3% maximum voltage drop allowed at design load
  - These are more stringent than non-enforceable requirements in the National Electric Code (NEC)

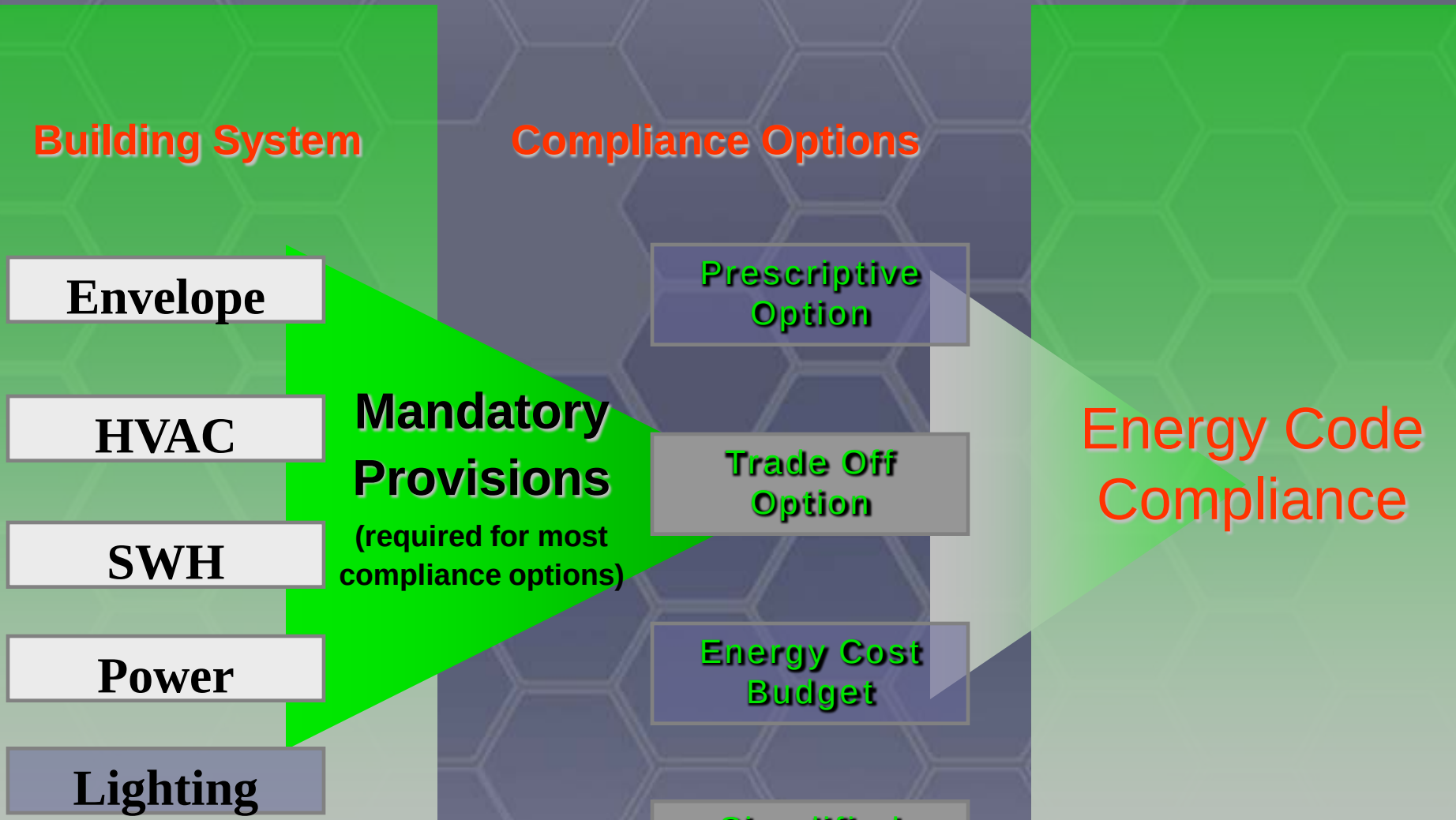


Power Submittals

Section 8.7

- Owner gets information about the building's electrical system
  - Record drawings of actual installation within 30 days
    - Single-line diagram of electrical distribution system
    - Floor plans showing location and areas served for all distribution
  - Manuals
    - Submittal data stating equipment rating
    - O&M manuals for equipment
    - Qualified service agency
    - Complete narrative of system as it's normally intended to operate

Lighting Compliance



Section 9 - Lighting

- General Application *(Section 9.1)*
  - Scope
  - Lighting Alterations
  - Installed Interior Lighting Power
  - Luminaire Wattage
- Compliance Path(s) *(Section 9.2)*
- Mandatory Provisions *(Section 9.4)*
  - Lighting control
  - Tandem wiring
  - Exit signs
  - Exterior building grounds lighting
  - Exterior building lighting power
- Building Area Method Compliance Path (*Section 9.5)*
- Alternative Compliance Path: Space-by-Space Method *(Section 9.6)*

Lighting General

- Scope
  - Interior spaces of buildings
  - Exterior building features
  - Exterior grounds lighting powered through building
  - Exceptions
    - Emergency lighting
    - Lighting required by life safety statute
    - Lighting within dwelling units of buildings
    - Decorative gas lighting

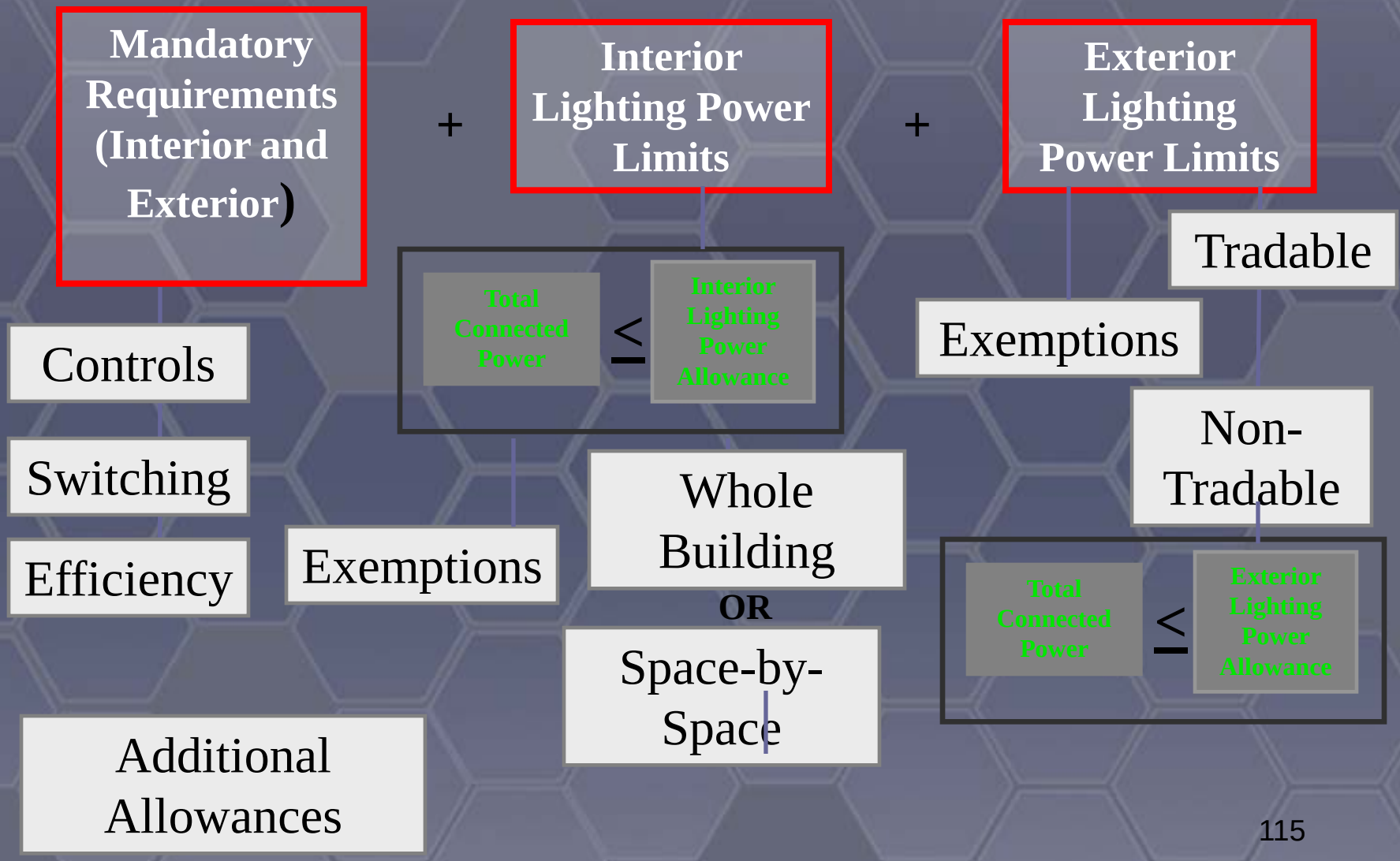
- Lighting Alterations – New lighting and lighting controls must comply with this section, unless an alteration replaces less than 50% of luminaires in a space and that alteration does not increase the installed lighting power

Lighting General

Section 9.1.3

- Installed Interior Lighting Power shall include all power used by the luminaires, including lamps, ballasts, transformers, and controls
  - **Exception**: in the case where there are two independently operated lighting systems that are controlled to prevent simultaneous operation
    - Include only the higher wattage system
- Luminaire Wattage for various systems shall determined in accordance with details in Section 9.1.4

Basic Lighting Requirements



Luminaire Wattage

Section 9.1.4

- Standard incandescent = max. labeled wattage of the luminaire
- Luminaires with ballasts or transformers = wattage of the maximum lamp/ballast combination OR max. labeled wattage of the luminaire
- Line voltage track = actual wattage with a min. 30 W per foot OR wattage limit of system's circuit breaker OR wattage limit of other permanent-current-limiting device(s) on the system
- Low voltage track = transformer wattage
- All others as specified on equipment

Mandatory: Individual Space Control

Section 9.4.1.2

- At least one for each room or space enclosed by ceiling-height partitions
  - in spaces ≤ 10,000 ft^2, each control serves 2500 ft^2 maximum and in spaces > 10,000 ft^2, serves 10,000 ft^2 maximum
- Readily accessible to occupants
- Remote location is allowed to accommodate areas where safety or security is a concern

Mandatory: Additional Space Controls

- Hotel/motel guest room lighting must be controlled at room entry

- Occupancy sensors are required in:
  - Classrooms (except shop, lab, K-12)
  - Conference/meeting rooms
  - Employee lunch/break rooms

Mandatory: Individual Space Control

- Additional control required for:
  - Display/accent lighting
  - Case lighting
  - Task lighting
  - Nonvisual lighting
  - Demonstration lighting

Mandatory: Automatic Shutoff

Section 9.4.1

- Automatic lighting shutoff control device required in all buildings larger than 5,000 ft^2
- Override of automatic shutoff required for not more than 4 hours
- Exceptions to automatic shutoff:
  - Lighting for 24-hour operation
  - Patient care spaces
  - Areas with safety or security concerns
- **Exception to 9.4.1.2a: Classrooms, conference/meeting rooms, and employee lunch and break rooms** with bi-level switching.

Mandatory: Automatic Shutoff

Section 9.4.1

- 9.4.1.2.1 Additional controls. Each area that is required to have a manual control shall have additional controls that meet the requirements of Sections 9.4.1.2.2.2 and 9.4.1.2.2.3.
- 9.4.1.2.2 Light reduction controls. Each area that is required to have a manual control shall also allow the occupant to reduce the connected lighting load in a reasonably uniform illumination pattern by at least 50 percent. Lighting reduction shall be achieved by one of the following or other *approved method:*
- a. Controlling all lamps or luminaires;
- b. Dual switching of alternate rows of luminaires, alternate luminaires or alternate lamps;

Mandatory: Automatic Shutoff

Section 9.4.1

- c. Switching the middle lamp luminaires independently of the outer lamps; or
- d. Switching each luminaire or each lamp.
- Exceptions:
- a. Areas that have only one luminaire.
- b. Areas that are controlled by an occupant-sensing device.
- c. Corridors, storerooms, restrooms or public lobbies.
- d. *Sleeping unit (see Section 505.2.3).*
- d. Spaces that use less than 0.6 watts per square foot (6.5 W/m2).
- 9.4.1.2.3 Automatic lighting shutoff. Buildings larger than 5,000 square feet (465m2) shall be equipped with an automatic control device to shut off lighting in those areas.

Mandatory: Automatic Shutoff

Section 9.4.1

- This automatic control device shall function on either:
- a. A scheduled basis, using time-of-day, with an independent program schedule that controls the
- interior lighting in areas that do not exceed 25,000 ft2 and are not more than one floor; or
- b. An occupant sensor that shall turn lighting off within 30 minutes of an occupant leaving a space; or
- c. A signal from another control or alarm system that indicates the area is unoccupied.
- Exception: The following shall not require an automatic control device:
- a. *Sleeping unit (see Section 505.2.3).*

Mandatory: Automatic Shutoff

Section 9.4.1

- b. Lighting in spaces where patient care is directly provided.
- c. Spaces where an automatic shutoff would endanger occupant safety or security.
- 9.4.1.2.4 Occupant override. Where an automatic time switch control device is installed
- to comply with Section 9.4.1.2.2.3, Item 1, it shall incorporate an override switching device that:
- a. Is readily *accessible.*
- b. Is located so that a person using the device can see the lights or the area controlled by that switch, or
- so that the area being lit is annunciated.
- c. Is manually operated.

Mandatory: Automatic Shutoff

Section 9.4.1

- d. Allows the lighting to remain on for no more than 2 hours when an override is initiated.
- e. Controls an area not exceeding 5,000 square feet (465 m2).
- Exceptions:
- a. In malls and arcades, auditoriums, single-tenant retail spaces, industrial facilities and arenas,
- where captive-key override is utilized, override time shall be permitted to exceed 2 hours.
- b. In malls and arcades, auditoriums, single-tenant retail spaces, industrial facilities and arenas, the
- area controlled shall not exceed 20,000 square feet (1860 m2).

Mandatory: Automatic Shutoff

Section 9.4.1

- 9.4.1.2.5 Holiday scheduling. If an automatic time switch control device is installed in
- accordance with Section 505.2.2.2, Item 1, it shall incorporate an automatic holiday scheduling feature
- that turns off all loads for at least 24 hours, then resumes the normally scheduled operation.
- Exception: Retail stores and associated malls, restaurants, grocery stores, places of religious worship and
- theaters.
- 9.4.1.2.6 Daylight zone control. Daylight zones, as defined by this code, shall be provided
- with individual controls that control the lights independent of general area lighting. Contiguous daylight

Mandatory: Automatic Shutoff

Section 9.4.1

- zones adjacent to vertical fenestration are allowed to be controlled by a single controlling device provided
- that they do not include zones facing more than two adjacent cardinal orientations (i.e., north, east, south,
- west). Daylight zones under skylights more than 15 feet (4572 mm) from the perimeter shall be controlled
- separately from daylight zones adjacent to vertical fenestration.
- 34
- Exception: Daylight spaces enclosed by walls or ceiling height partitions and containing two or fewer
- light fixtures are not required to have a separate switch for general area lighting.

Mandatory: Automatic Shutoff

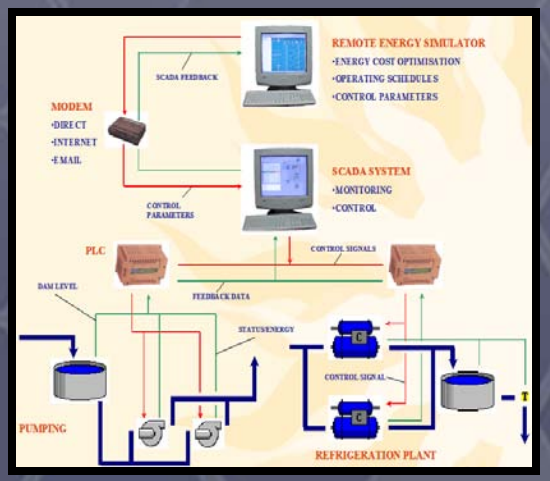
Section 9.4.1

- 9.4.1.2.7 Sleeping unit controls. *Sleeping units in hotels, motels, boarding houses or*
- similar buildings shall have at least one master switch at the main entry door that controls all permanently
- wired luminaires and switched receptacles, except those in the bathroom(s). Suites shall have a control
- meeting these requirements at the entry to each room or at the primary entry to the suite.

Automatic Shutoff

Section 9.4.1

- Compliance options:
- Control lights on a scheduled basis (automatic time switch)
  - Time-of-day controller
  - Controls ≤ 25,000 ft^2 and not more than one floor
- Occupant sensor
  - Turn lights off within 30 minutes of occupant leaving the space
- Signal from another control or alarm that indicates the area is unoccupied



Lighting - MP

Application of Automatic Shutoff

Intent is to apply to business entities or structures where whole building control is practical

Example application:

– Strip mall – individual business unit

Exterior Lighting Control Section 9.4.1.3

- For dusk-to-dawn lighting: astronomical time switch or photosensor
- For all other: astronomical time switch **OR photosensor + time switch [REVISED!]**
- All time switches must have 10 hour battery backup
- Exceptions:
  - Covered vehicle entrances
  - Exits from buildings or parking structures
  - (where required for safety, security, or eye adaptation)

Lighting - MP

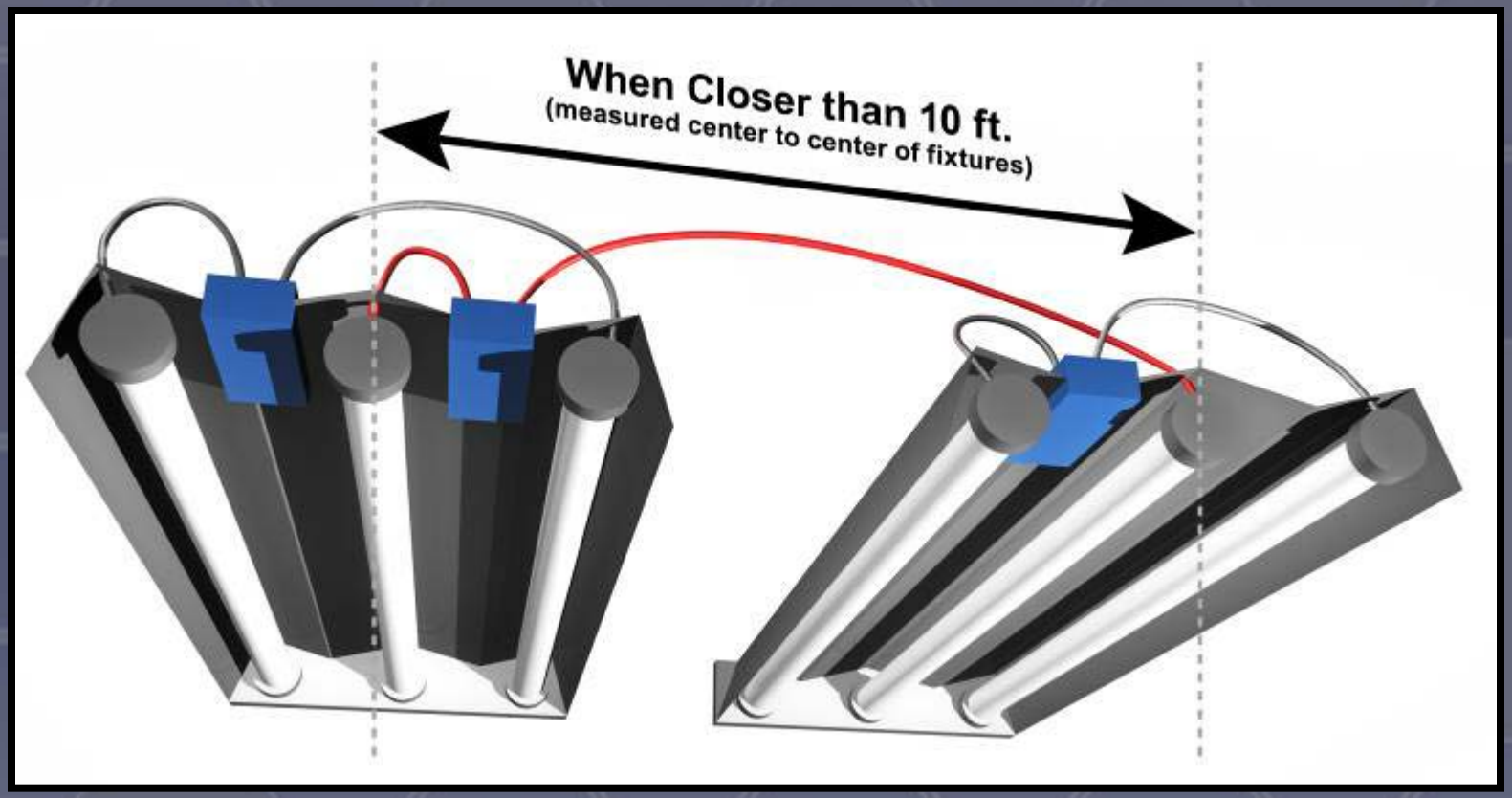
Additional Control

- Many special lighting applications must be controlled separately
  - Display/accent lighting
  - Case lighting
  - Hotel/motel guest room lighting
  - Task lighting
  - Nonvisual lighting
  - Demonstration lighting

Section 9.4.1.4

Tandem Wiring

Section 9.4.2



Eliminate use of single lamp, low-frequency ballast where possible

Lighting - MP

Tandem Wiring Exceptions

Section 9.4.2

- Separated surface or pendant luminaires
- Recessed luminaires more than 10 ft apart
- Other luminaires
  - With three-lamp ballasts
  - On emergency lighting circuits
  - With no available pair
  - With one lamp, high frequency, electronic ballast

Exit Signs

Section 9.4.3

- Limited to 5 watts per face

Exterior Lighting Power

- Building grounds lighting luminaires over 100 watts must have lamp efficacy of at least 60 lumen/Watt
- Exterior Building Lighting Power must meet prescribed wattage limits. Exterior applications divided into 2 categories:

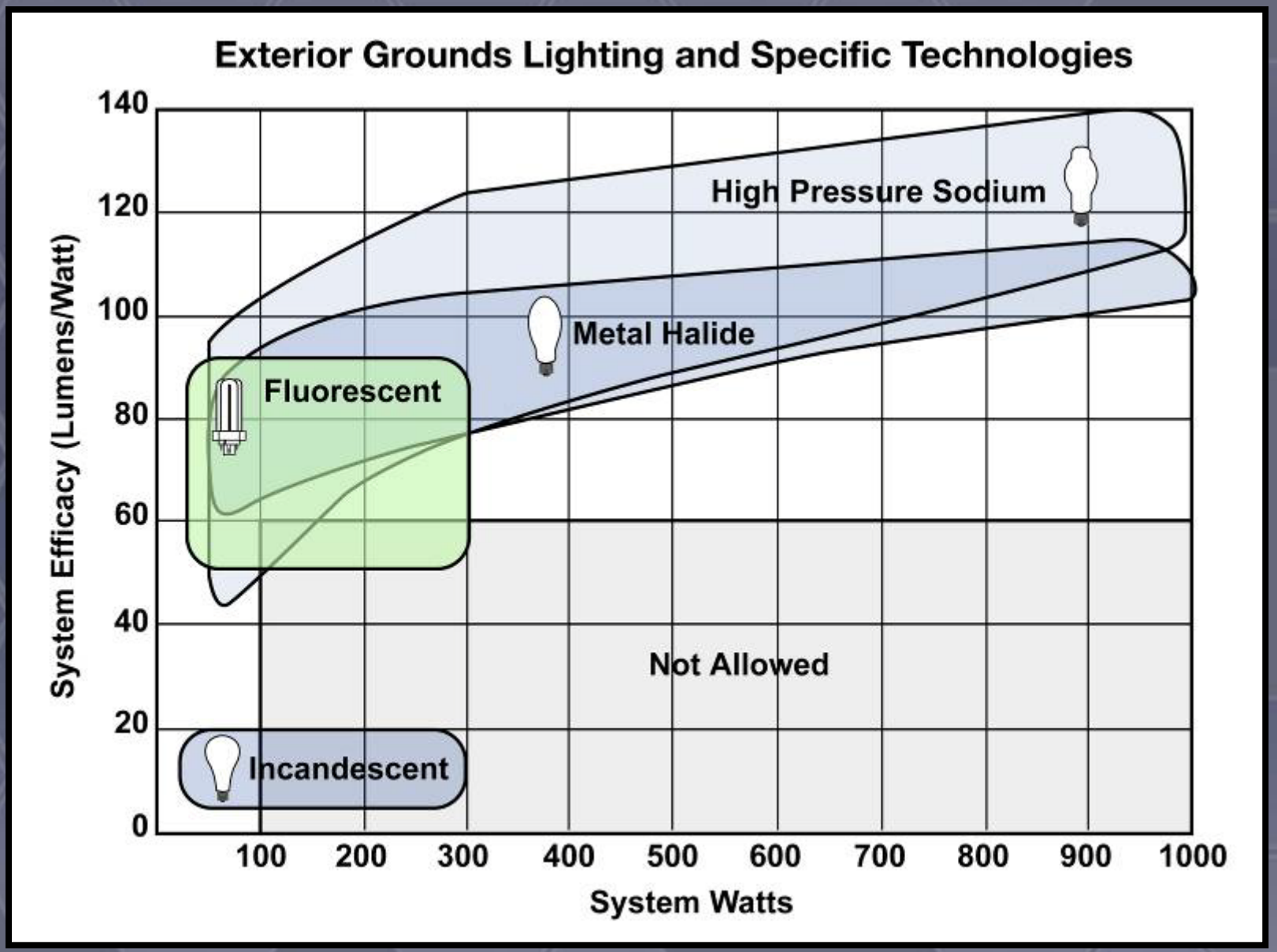
Tradable: allowed wattage may be traded among these applications

Non-Tradable: allowed wattage **cannot** be traded between surfaces or with other exterior lighting

Efficacy

- The ratio of light output to watts input
  - lumens per watt
- The higher the efficacy, the more efficient the light source
  - 40 watt incandescent = 480 lumens
  - 40 watt fluorescent = 2640 lumens

Efficacy


Exterior Grounds Lighting and Specific Technologies
System Efficacy (Lumens/Watt)
140
120
100
80
60
40
20
0
High Pressure Sodium
Metal Halide
Fluorescent
Not Allowed
Incandescent
100
200
300
400
500
600
700
800
900
1000
System Watts

Exterior Building Lighting Power

Section 9.4.5

- The total exterior lighting power allowance is the sum of the individual lighting power densities [LPD]….
- ….plus an additional unrestricted allowance of 5% of that sum. Trade-offs are allowed only among “Tradable Surfaces” applications.
- Some exemptions apply

Exterior Building Lighting Power

Section 9.4.5

- Lighting used for the following exterior applications is exempt when equipped with a control device independent of the control of the nonexempt lighting:
  - specialized signal, directional, and marker lighting associated with transportation;
  - lighting that is integral to advertising signage or directional signage;
  - lighting that is integral to equipment or instrumentation and is installed by its manufacturer;
  - lighting for theatrical purposes, including performance, stage, film, and video production;
  - lighting for athletic playing areas;
  - temporary lighting;
  - lighting for industrial production, material handling, transportation sites, and associated storage areas;
  - theme elements in theme/amusement parks;
  - lighting used to highlight features of public monuments and registered historic landmark structures or buildings.

Lighting - P

Exterior LPDs: 90.1-2007

Applications	Lighting Power Densities
Tradable Surfaces (Lighting Power Densities for open parking areas, building grounds, building entrances and exits, canopies and overhangs, and outdoor sales areas may be traded)	
Uncovered Parking Areas	
Parking lots and drives	0.15 W/ft^2
Building Grounds	
Walkways less than 10 feet wide	1.0 W/linear foot
Walkways 10 feet wide or greater, Plaza areas and Special feature areas	0.2 W/ft^2
Stairways	1.0 W/ft^2

Exterior LPDs: 90.1-2007

Applications	Lighting Power Densities
More Tradable Surfaces…	
Building Entrances and Exits	
Main entries	30 W/linear foot of door width
Other doors	20 W/linear foot of door width
Canopies and Overhangs	
Canopies (free standing & attached) and overhangs	1.25 W/ft^2
Outdoor Sales	
Open areas (including vehicle sales lots)	0.5 W/ft^2
Street frontage for vehicle sales lots in addition to “open area” allowance	20 W/linear foot

Exterior LPDs: 90.1-2007

Applications	Lighting Power Densities
Non-Tradable Surfaces (Lighting Power Density calculations for the following applications can only be used for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the Tradable Surfaces section of this table.)	
Building facades	0.2 W/ft^2 for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length
Automated teller machines & night depositories	270 W per location plus 90 watts per additional ATM per location
Entrances and gatehouse inspection stations at guarded facilities	1.25 W/ft^2 of uncovered area (covered areas are included in the Canopies and Overhangs section of Tradable Surfaces)

Exterior LPDs: 90.1-2007

Applications	Lighting Power Densities
Non-Tradable Surfaces	
Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.5 W/ft^2 of uncovered area (covered areas are included in the Canopies and Overhangs section of Tradable Surfaces)
Drive-up windows at fast food restaurants	400 W per drive through
Parking near 24-hour retail entrances	800 W per main entry

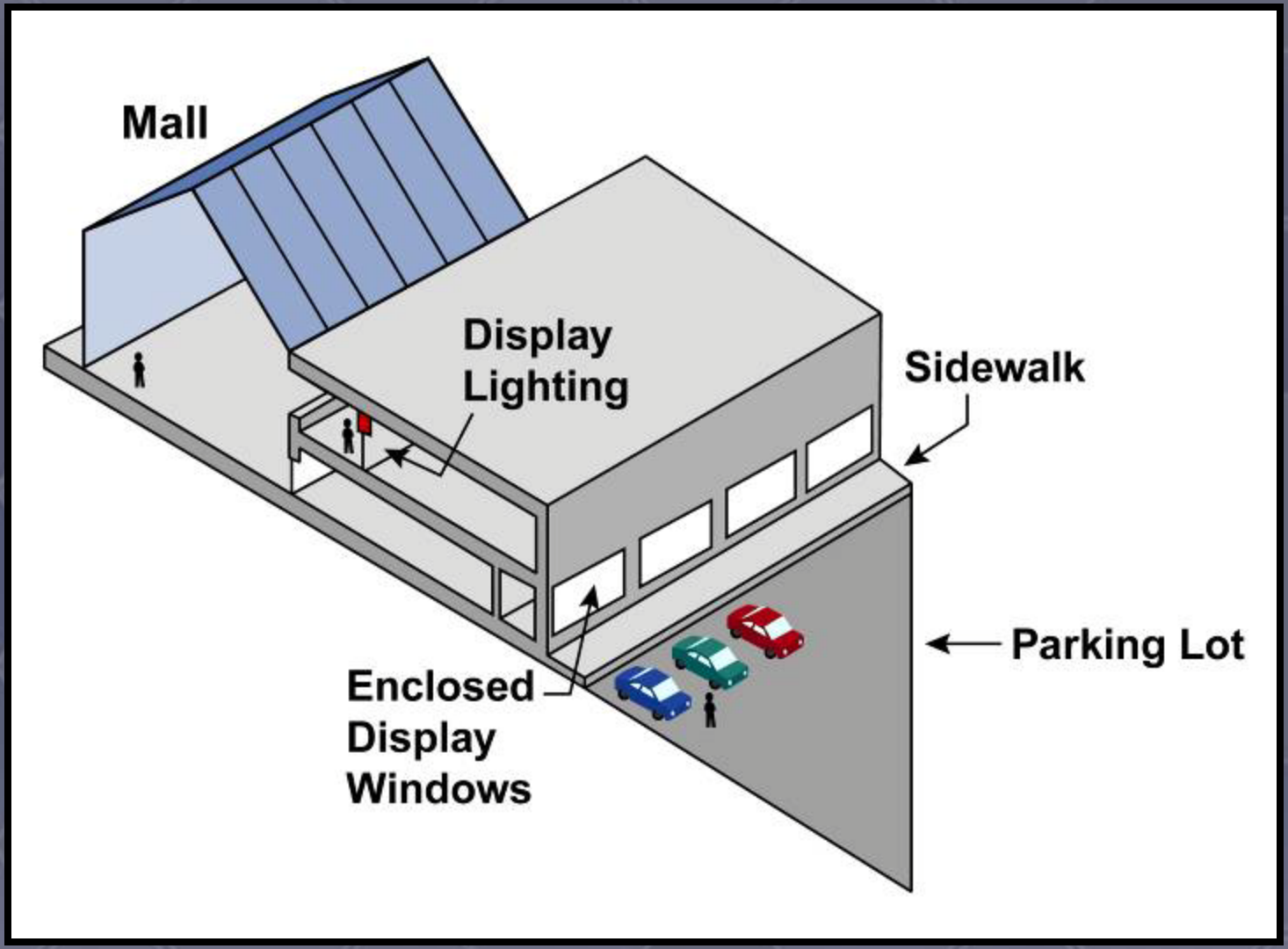
Interior Lighting Power

- Lots of exemptions
- Calculation methods
  - Building area
  - Space-by-space
  - Trade-offs of interior lighting power allowance among portions of the building for which a different calculation method has been used is not permitted

Lighting Power Allowance Exemptions

- Theatrical, stage, film, and video production
- Medical and dental procedures
- Exhibit displays for museums, monuments, and galleries
- Plant growth or maintenance
- Integral to equipment or instrumentation installed by manufacturer
- Integral to both open and glass-enclosed refrigerator and freezer cases
- Retail display windows, provided the display is enclosed by ceiling-height partitions
- Food warming and food preparation equipment
- Interior spaces specifically designated as registered interior historic landmarks
- Integral part of advertising or directional signage
- Exit signs
- Sale or lighting educational demonstration systems
- Lighting for television broadcasting in sporting activity areas
- Casino gaming areas
- Furniture-mounted supplemental task lighting controlled by automatic shutoff and complying with 9.4.1.4(d)
- For use in areas specifically designed for occupants with special needs

Exemption Example



Building Area Method of Calculating Interior Lighting Power Allowance

Section 9.5.1

- Used for projects involving
  - An entire building
  - A single, independent, and separate occupancy in a multi-occupancy building
- Gross lighted area is multiplied by allowance from Table 9.5.1
- Limitations
  - Insensitive to specific space functions and room configurations
  - Generally is more restrictive
  - Does not apply to all building types - but “selection of a reasonably equivalent type” is permitted

Gross Lighted Area

- Sum of total lighted area of a building
  - Measured from the exterior faces of the exterior walls or from the centerline of walls separating buildings, but excluding a long list of areas. (See Standard).
- Used in the building area method of determining interior lighting power allowance

Building Area Allowances

- Table 9.5.1

Building Type	Lighting Power Density (W/ft^2)
Automotive Facility	0.9
Convention Center	1.2
Court House	1.2
Dining: Bar Lounge/Leisure	1.3
Dining: Cafeteria/Fast Food	1.4
Dining: Family	1.6
Dormitory	1.0
Exercise Center	1.0
. . .	. . .

Space-by-Space Method of Calculating Interior Lighting Power Allowance

Section 9.6.1

- Identify different building types in your project
- Divide gross lighted area of the building into each of the space types
- Calculate lighting power allowance by multiplying area of space type by lighting power density for that specific space type
- Sum all the allowances
- Advantages
  - More flexible
  - Applicable to all building types
  - Accounts for room geometry (e.g., lighting needs of enclosed office vs. open office)

Additional Interior Lighting Power

Section 9.6.2

- An increase in the ILPA is allowed for specific space functions when using the space-by-space method. Applications must be automatically controlled, separately from the general lighting, to be turned off during non-business hours
  - Decorative in addition to general lighting – 1.0 W/ft^2 in space used
  - Retail display lighting

Lighting - P

Retail Display Lighting

Additional Interior Lighting Power Allowance = 1000 watts +
(Retail Area 1 x 1.0 W/ft2) +
(Retail Area 2 x 1.7 W/ft2) +
(Retail Area 3 x 2.6 W/ft2) +
(Retail Area 4 x 4.2 W/ft2),

Where:

Retail Area 1 = the floor area for all products not listed in Retail Area 2, 3 or 4.

Retail Area 2 = the floor area used for the sale of vehicles, sporting goods and small electronics.

Retail Area 3 = the floor area used for the sale of furniture, clothing, cosmetics and artwork.

Retail Area 4 = the floor area used for the sale of jewelry, crystal, and china.

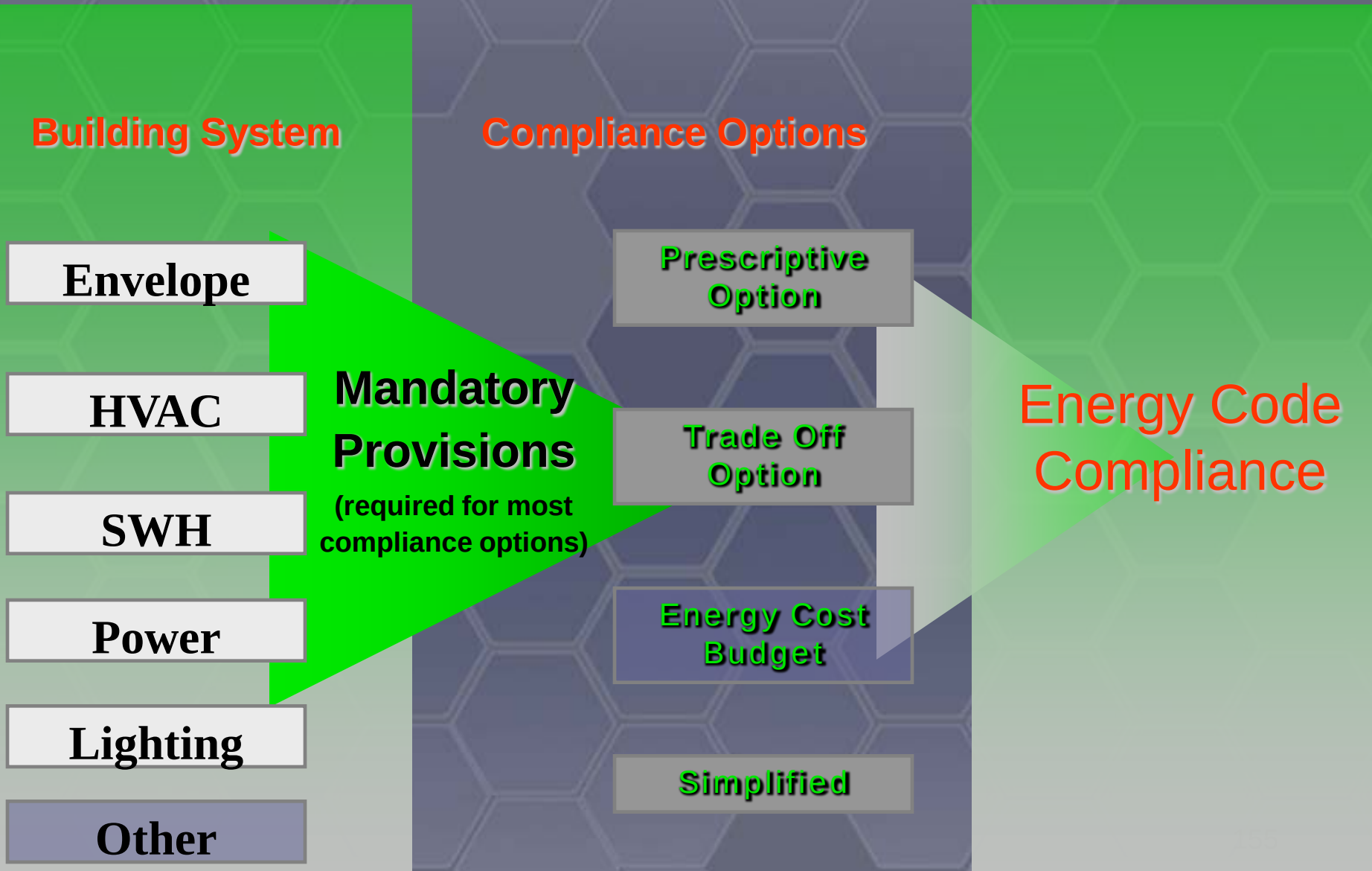
Exception: Other merchandise categories may be included in Retail Areas 2 through 4 above, provided that justification documenting the need for additional lighting power based on visual inspection, contrast, or other critical display is approved by the authority having jurisdiction.

Submittals

Section 9.7

- There are no submittals associated with the lighting requirements

Other Compliance



Section 10 - Other Equipment

- Motor efficiency levels correspond to Energy Policy Act of 1992 manufacturing standards
- Mandatory provisions are for General Purpose Design A and Design B motors only
- Motors in new buildings, additions to existing buildings, and alterations to existing buildings must comply
  - Relocated or reused existing motors do not have to meet these requirements
- No small building option, no prescriptive compliance path, no alternative compliance paths, no submittals

Section 11 - Energy Cost Budget Method

Section 11

- The ultimate trade-off method allowing you to trade-off across building systems through the use of annual, hourly simulation tools and a baseline building
- The only real way to deal with unique designs, renewables, high-efficiency equipment, etc.
- The basis of the energy portion of the LEED rating
- Limits allowable energy costs of the design to those of a building meeting the Standard
- Buildings must still meet all mandatory requirements (Section X.4)

Section 11 - Energy Cost Budget Method

Section 11.1

- Tradeoff limited to building permit
- You have to have an approved building envelope design prior to ECB submittal
- You must meet all the X.4 sections AND the design energy cost cannot exceed the energy cost budget AND the energy efficiency level of components must meet or exceed the levels used to calculate the design energy cost
- You must document all this in great detail

Section 11 - Energy Cost Budget Method

Section 11.2

- Use a good and approved simulation program
- Use appropriate and approved climate data
- Use appropriate and approved purchased energy rates
- Use the same simulation program, climate data, and purchased energy rates for both the design energy cost and energy cost budget
- Get approval to deal with exceptional calculations that aren’t covered in the simulation program

Section 11 - Energy Cost Budget Method

Section 11.3

- Develop your proposed building design and budget building design in accordance with Table 11.3.1
  - This table “locks down” a number of building design parameters
- Choose your budget building HVAC system from Figure 11.3.2 and Table 11.3.2A

Section 11 - Energy Cost Budget Method

Section 11

- If you are attempting to show that your building goes “above code” (say, for instance, for LEED energy points) as opposed to simply using ECB as a very flexible and complex code compliance tradeoff option,
  - be sure to see Informative Appendix G, which contains many of the same elements as Section 11, but with modifications to accommodate the needs of “above code” programs

Section 12 - Normative References

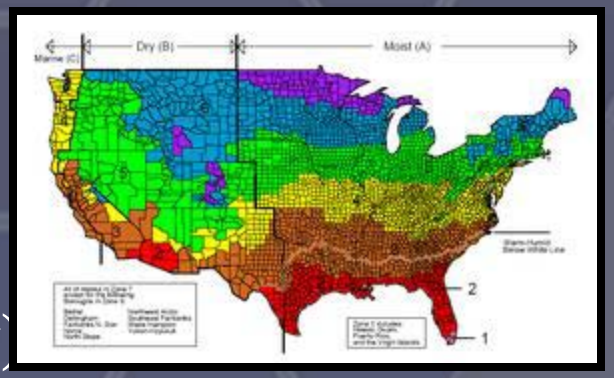
- Normative (read “mandatory”) reference documents
- Includes test methods, rating procedures, and other standards

Rated R-Value of Insulation and Assembly U-Factor, C-Factor, and F-Factor Determinations

- Includes pre-calculated U-factors, C-factors, and F-factors
  - Above-grade walls
  - Below-grade walls
  - Floors
  - Slab-on-grade floors
  - Opaque doors
  - Fenestration

Building Envelope Climate Criteria

- Defines which of the envelope criteria tables (Tables 5.5-X) to use for your location
- General
  - Climate Zone Map
  - U.S. Climate Zones (by County)
  - Canadian Climatic Zones (by City)
  - International Climate Zone (by City)
- Major Climate Type Definitions (for use with non-U.S. locations)



Methodology for Building Envelope Trade-Off Option in Subsection 5.6

- The details of how the envelope trade-off option referenced in Section 5.6 is implemented
- This methodology is implemented in the ENVSTD
  software distributed with the 90.1 Users Manual

Climate Data

- Climatic data for a number of US, Canadian, and international locations
  - HDD65 and CDD50
  - Heating and cooling design temperatures
  - “number of hours between 8 am and 4 pm with Tdb between 55 and 69”
- Used exclusively for HVAC calculations

Normative Appendix D

Informative References

- Other useful references that are not mandatory, but are useful as examples for the user of Standard 90.1-2007
- In general, these are not consensus documents so ASHRAE procedures do not allow them to be mandatory references

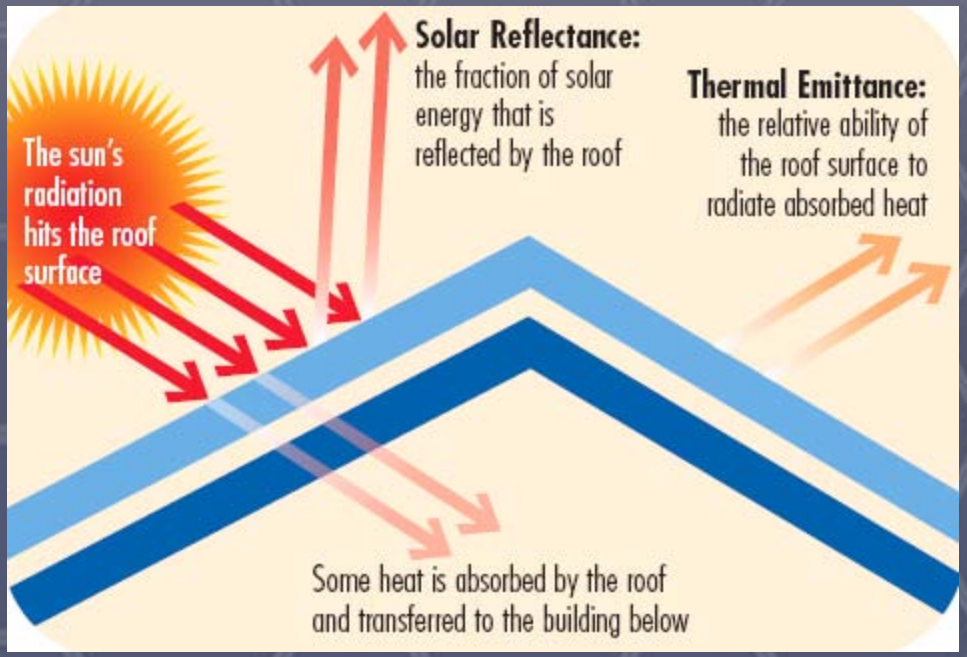
Addenda Description Information

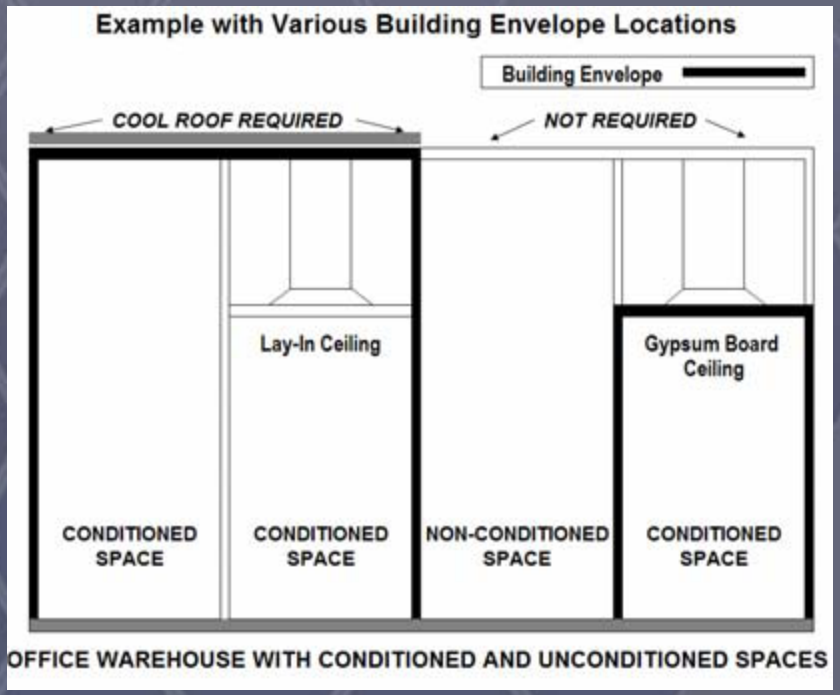
- Information on addenda to ANSI/ASHRAE/IENSA Standard 90.1-2004 (the predecessor to Standard 90.1-2007)
- ASHRAE issued 44 addenda to Standard 90.1-2004
- Standard 90.1-2004 plus these addenda forms the basis of Standard 90.1-2007

Performance Rating Method

- Instructions for using the ANSI/ASHRAE/IESNA Standard 90.1-2007 Energy Cost Budget Method in conjunction with the U.S. Green Buildings Council (USGBC) Leadership in Energy and Environmental Design (LEED) program

COOL ROOFS!!!


Solar Reflectance:
the fraction of solar energy that is reflected by the roof
Thermal Emittance:
the relative ability of the roof surface to radiate absorbed heat
The sun's radiation hits the roof surface
Some heat is absorbed by the roof and transferred to the building below



Informative Appendix H

END MEP

Economizers

- Climate and size dependent (Table 6.5.1)
- There are LOTS of exceptions
- Can use air economizers
  - 100% of design supply air
  - Sequenced with mechanical cooling equipment
  - High limit shutoff
  - Dampers
- Can use water economizers
  - 100% of expected system cooling load at 50°F DB, 45°F WB
  - Maximum pressure drop limitation

Section 6.5.1

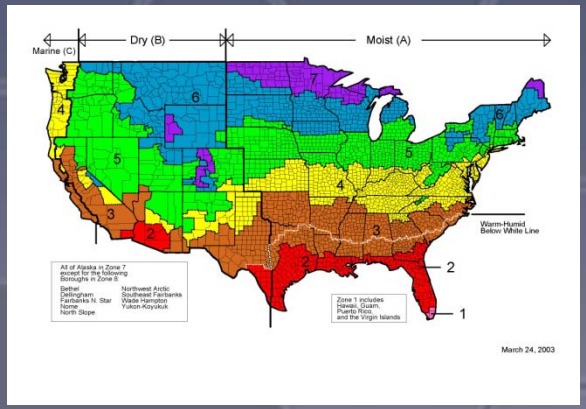
HVAC - P

Economizer Exceptions

- Exceptions:
  - Cooling capacity - Table 6.5.1
  - Systems with gas phase air cleaning per Standard 62
  - Where >25% of the air must be humidified >35°Fdp
  - Systems with condenser heat recovery per 6.5.6.2
  - Residential systems <5X limits in Table 6.5.1
  - Systems with a balance point <=60°F
  - Systems expected to operate < 20hrs/wk
  - Systems serving zones with refrigerated casework
  - Where cooling efficiency exceeds Table 6.3.2

Economizers (Table 6.5.1)

Climate zone	Cooling capacity for which an economizer is required
1a, 1b, 2a, 3a, 4a (Miami, St. Louis, Charlotte)	**Economizer unnecessary**
2b, 5a, 6a, 7, 8 (Yuma, Chicago, Edmonton)	**≥ 135,000 Btu/h**
3b, 3c, 4b, 4c, 5b, 5c, 6b (Denver, Lubbock, Vancouver)	**≥ 65,000 Btu/h**



Design Capacity – Air Economizers

- System capable of modulating outside air and return air dampers to provide up to 100% of the design supply air quantity as outside air for cooling

Section 6.5.1.1

HVAC . P

Control Signal

- Dampers capable of being sequenced with the mechanical cooling equipment and shall not be controlled by only mixed air temperature
- Exception
  - Systems controlled from space temperature (such as single-zone systems)

Section 6.5.1.1.2

HVAC . P

High Limit Shutoff

- Automatically reduce outdoor air intake to minimum outdoor air quantity when outdoor air intake will no longer reduce cooling energy usage
- Control types for specific climates from Table 6.5.1.1.3A
- Settings from Table 6.5.1.1.3B

Section 6.5.1.1.3

HVAC - P

Dampers

- Return air and outdoor air dampers to meet the damper leakage specified in 6.4.3.4.4

Section 6.5.1.1.4

HVAC - P

Relief of Excess Outside Air

- Means to relieve excess outdoor air during economizer operation to prevent overpressurizing the building
- Outlet located to avoid recirculation into the building

Section 6.5.1.1.5

HVAC - P

Design Capacity – Water Economizers

- System capable of cooling supply air by indirect evaporation and providing up to 100% of expected system cooling load at outside air temperatures of 50°F dry bulb/45°F wet bulb and below
- Exception
  - You can also meet this requirement if your design can meet 100% of expected cooling load at 45°F dry bulb/40°F wet bulb

Section 6.5.1.2.1

HVAC .P

Maximum Pressure Drop

- Precooling coils and water-to-water heat exchangers to have either
  - Water-side pressure drop of < 15 ft of water **OR**
  - Bypassed when not in use

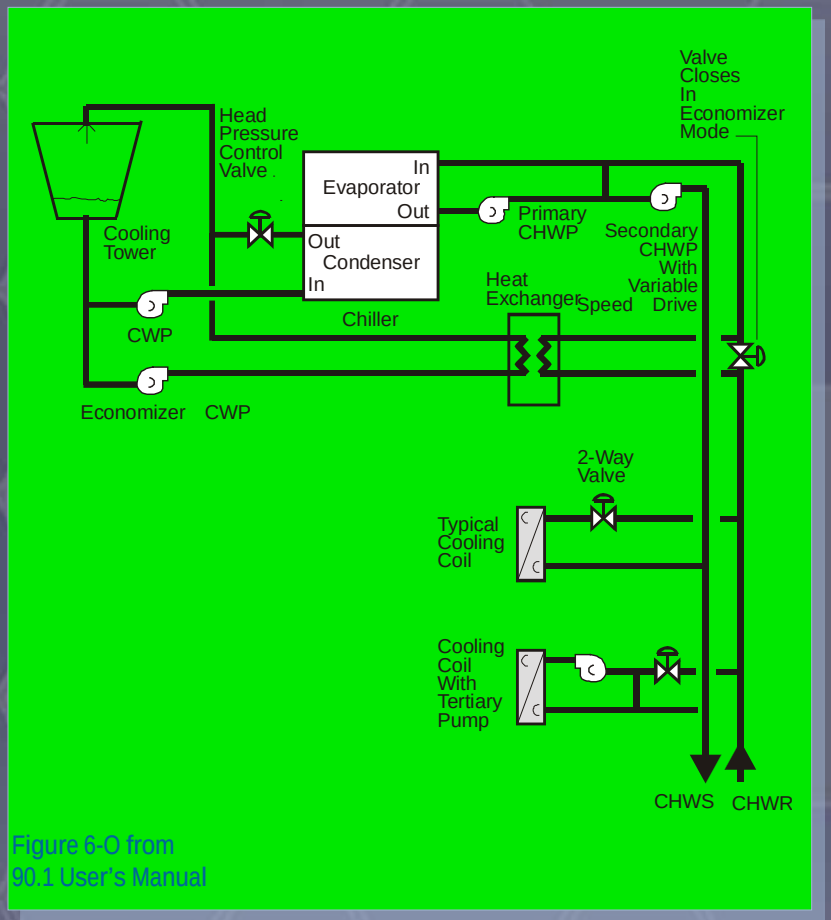


Figure 6-O from 90.1 User's Manual

Section 6.5.1.2.2

HVAC - P

Integrated Economizer Control

- Economizers must be integrated with mechanical cooling systems and be capable of providing partial cooling even when additional mechanical cooling is required
- Some exceptions to this

Section 6.5.1.3

HVAC - P

Economizer Heating System Impact

- Designed so economizer operation doesn't increase the building heating energy use during normal operation
- Exception
  - Economizers on VAV systems that cause zone level heating to increase due to a reduction in supply air temperature

Section 6.5.1.4

HVAC - P